

# Electrochemical and Metallurgical Industry

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## **Electrochemical and Metallurgical Industry**

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### Our Third Volume and Our Regular Departments.

This issue, which closes our third volume, is accompanied by the yearly index, which we trust may prove a useful and efficient key to the contents of the volume. An index is, in itself, a most concise summary. It would serve no useful purpose to try and summarize it again, but a few words may be said here concerning the serials and concerning the regular departments in our columns during the past year. Mr. F. A. J. FitzGerald's serial on electric resistance furnaces, which was started in our second volume, is now almost completed, and will form a most valuable treatise of an authoritative character in view of the author's long connection with the two most important electric resistance furnace industries in this country. In our March issue of the present volume, the first installment appeared of Dr. J. W. Richards' serial on metallurgical calculations, which has found an enthusiastic reception everywhere in metallurgical circles. It will be continued during the next year.

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What may be called more properly regular departments are our Analysis of Current Electrochemical Patents, the Digest of United States Patents, the Synopsis of Periodical Literature, the Recent Metallurgical Patents and the Notes on Electrochemistry and Metallurgy in Great Britain. The last-named department appeared for the first time in the first issue of the present volume; it serves the important purpose of maintaining the continuity between the old and the new metallurgical and electrochemical world. The department dealing with Recent Metallurgical Patents and the Synopsis of Periodical Literature have remained the same as in the second volume, except that in the Synopsis more space has been allotted to the discussion of metallurgical subjects. To the many new readers which have been won for this journal during the last year an explanation, however, appears to be necessary concerning the difference between the Analysis of Current Electrochemical Patents and the Digest of United States Patents prior to July, 1902. The "Analysis" always covers those patents which have been issued during the past month or so, and covers all fields of electrochemistry and electrometallurgy. In this department the electrochemical United States patents issued since July, 1902, have been covered in our first three volumes. Of course, since the patents had to be analyzed as soon as issued, no detailed classification has been possible in this department. The case is absolutely different with the Digest of United States Patents prior to July, 1902. This department intends to cover all electrochemical and electrometallurgical United States patents which were issued before this journal was started. In this department the patents are classified according to subject matters. To get a complete record of all patents on any one subject, both the "Analysis" and the "Digest" should therefore be consulted.

### Accuracy of Chemical Analysis.

We conclude in this issue an article by Mr. Thorn Smith, of the Ducktown Sulphur, Copper & Iron Co., Ltd., on a cooperative analysis of copper slag. This is a subject of great general importance, for analytical chemistry is the basis of all metallurgical work, as it is of all chemical knowledge in general. An accurate method of analysis of a properly prepared sample is a *sine qua non* in a smelting plant. Not only are the purchases of the ore made from the certificates of the chemist, but analyses of the ores, slags, matte, metal, coal, coke, etc., are the only sure guide to the superintendent when things are going wrong in the plant. Now, it is apparent that inaccurate and false data can disturb the whole line of argument by which the trouble is diagnosed. For instance, in the operation of a lead furnace excessive care must be observed to keep the slag of right chemical composition. If the conditions are not just right and all do not fit together like the stones of an arch, "a thousand dollars worth of lead and silver" can easily be put over the dump each day in the form of "foul slag." So it is seen that the results of poor analytical work can easily cause great and direct financial loss.

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Mr. Smith has, in his own initiative, taken up this work of investigating the methods and checking one method against another, and has also eliminated the personal equation by checking work of different analysts against each other. While it would be irrelevant to enter into the discussion here of the various methods, yet we can say that as the result of investigations "the true has been sifted from the false"—a process described by Kant, the great philosopher, as the right way to approach the truth. We know that all chemists must feel indebted to Mr. Smith for his unselfish labor to put technical chemistry on a surer foundation. The work should be taken up broadly and elaborated by the Geological Survey in conjunction with the Carnegie Institute and the committee appointed by the American Chemical Society. It is a field for organized effort by several public institutions rather than by any one person. The fact that Mr. Thorn Smith devoted so much time from the busy life of a works-chemist to take this important subject in hand, is a fact that evidences his American public spirit.



### Business Activity.

There is unquestionably sweeping over this country a wave of prosperity which is the reaction from the period of slight inactivity in 1904. Perhaps the best indication of this is the fact that all the metal markets, especially that of copper, have shown decided strength during the past summer before the usual October purchases. Crop reports from the West assure us of a continuance of this state for at least a year, for it is founded on a safe and sure foundation of elemental wealth. Mr. James J. Hill, on a recent tour in the Northwest, where the fresh air from the prairie loosened his tongue, so silent in the vicinity of Wall Street, proclaimed prosperity for these States, because "all wealth comes originally from farms, mines, seas and forests, and all these are now abundant producers." These, of course, are the basic wealth of all countries, only needing development by an energetic and intelligent race. The old "spelling book" rhyme, ending with the

refrain, "the farmer he must feed them all," is as true as ever, but in an age of metals and steam engines, mineral wealth is of almost equal importance. There is a curious concatenation of circumstances that makes for prosperity, well illustrated by a story from the breezy, virile West. A rich old farmer drove a herd of hogs to the station, to be converted into a variety of products, varying from spare-ribs to perfumed toilet soap, at one of the large packing houses of the West. When asked what he was going to do with the substantial check he received he said, "Buy more land." But they said, "What are you going to do with that land?" "Raise more corn," was the answer. And "with the corn?" "Feed more hogs." "But with all those hogs?" "Sell 'em." "And with that money?" "Buy more land." And then he repeated that series of monosyllabic words, "Land, Corn, Hogs, Money," to his infinite satisfaction.

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Such a bourgeois anecdote finds direct and concrete application in the metal business. It is mines, metals, money, more mines, more metals, more money. This is the essential reason of the expansion of the metal industry. And figures which do not prevaricate show this. Consider iron, copper and lead the most important commercial metals. The percentage increase in these from 1895 to 1904 has been as follows, according to the statistics of the United States Geological Survey: The output of pig iron in the United States increased in those nine years by 75 per cent, and we should here consider the relative inactivity in the iron industry in 1904. If for 1905 we assume an output of 20,000,000 long tons only, the increase in the output from 1895 to 1905 will amount to 110 per cent. The cash value of the output of pig iron increased from 1895 to 1904 by 102 per cent. The output of copper increased in the same nine years by 111 per cent, while the increase in value of the copper produced amounted to 178 per cent. The lead production increased by 80 per cent, the value by 136 per cent. With great improvement in the size and the mechanical features of metallurgical apparatus, have come great advances in the knowledge of the proper metallurgical conditions—to operate a plant at its maximum efficiency. Our national prosperity is due originally to striving for ideals of perfection, just as Germany has turned from a nation of philosophers to a nation of engineers. Sentiment, thought and reason govern men's action, and unless this strain is held, our prosperity cannot long endure, and the spirit of the American pioneer flowering in these material achievements will perish. But the reserve democratic spirit of our country is stronger than ever, and it will be an ever-present help in time of trouble.



### Novelties in Water-Cooling Furnaces.

There is no better way to preserve a refractory material than to place in proximity to it an iron backing which is continuously cooled by a stream of water. This was originally done by laying between the courses of brick, water pipes. This had the practical result in the old brick shaft-furnaces of making extremely long campaigns. The final evolution of this idea was the water-jacketed copper furnace, where no refractory lining was provided between steel jackets and melting zone. The chilled slag immediately formed a natural refractory lining to the furnace. There was considerable talk at

the time of the wide introduction of this innovation some fifteen years ago, that the water cooling would increase heat losses largely, and thus increase the amount of fuel per ton of ore. However, Mr. J. B. F. Herreshoff published some tests on the amount of heat lost in feed-water, and proved that only some 5 per cent of total heat was lost in water from jackets.

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The usual way of applying this water on a lead or copper furnace is by circulating it through metallic jackets. These jackets are usually cast iron or pressed steel, though cast steel and cast copper have been employed. Signor E. Ferraris, a brilliant metallurgist, of the Montepioni Co., of Sardinia, has built a lead furnace with the crucible made of cast-steel bolted segments cooled by a spray of water. Provided the film of water is always on this steel plate, the temperature must be less than 100° C., and thus the result is the same as if there was a 2-inch stream of water there, or even the Atlantic Ocean. This construction of Ferraris, used in iron blast furnaces to some extent, is better than jackets, mechanically, moreover, it is cheaper. There is also no danger of steam pockets or mud filling up the bottom of the jacket. We expect to see this scheme adopted in the United States to some extent in the future.

\* \* \*

In the iron blast furnaces much use has been made of the so-called "bosh plates," which are in essence a series of diminutive water jackets. They are often placed so near together that a modern furnace is one large mass of plumbing. The construction is extremely complicated, and means that much care is necessary to stop leaks. In Germany, Burgess has seized the bull boldly by the horns and has constructed at Geismar a furnace cased entirely by bolted cast-iron sections and lined with only some 3 inches of firebrick. This furnace is water cooled by a spray of water from top to bottom. It has been operated continuously for four years, and there is no reason to believe that it will ever burn out its lining. Its slightly increased fuel consumption is compensated for by long campaign. This idea will be taken up by prominent steel companies of America, since the refractory lining of an iron blast furnace is uncertain and unsatisfactory.

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### Metallurgical Book-Keeping.

In the past ten years there has been a friendly invasion of this country by the class of "chartered accountants" from England and Scotland. Their reception here has been due quite largely to the formation of the large corporation. In a big concern, organization is essential. Cost-keeping and accounting has been developed as a science abroad, and those who practice it belong to a most important profession. The art of the statistician must be mixed with good, common sense. Strikingly similar to conditions in practical work, theory and practice must be harmoniously wedded. In a large metallurgical works there is present the sum of the concrete experience of all those who at furnace or desk have labored to bring the plant to its maximum efficiency. The result is a human institution more or less imperfect. Now, we believe that it would not be impossible to apply the methods of the "constructive accountant" to preserve these records in definite and "get-at-

able" form. Of course, the personal factor is important, and the keen eye of the expert steel roller or old furnaceman could never be mummified and placed in a vault for purposes of record. But this very example indicates important possibilities. The trained eye of the furnaceman employs by intuition some sort of optical pyrometry. By the commercial use of optical pyrometers or of pyrometers of other kind—there are now quite a number of reliable instruments available—it becomes possible to record the proper sequence of the temperatures in a process and to duplicate it exactly from the record, after it has once been determined. The secret is then no longer locked up in the personal experience of a few men. In the same way it would be well in general to bring all this accumulated experience to some definite system, so that, to assume an impossible case, the entire metallurgical force could be blotted out of existence, and their successors would have some actual tangible basis on which to build future results.

\* \* \*

Of course, such a set of metallurgical books explaining the irregularities of operation of the different departments would, unless opened by an expert, be clumsy and unwieldy. For following the thought of the foregoing paragraph, it is impossible to create Pygmalion-like flesh and blood out of a graven statue. Nevertheless, even to the best of practical men, systematic records are invaluable. And this scheme, if adapted to meet actual conditions, to be flexible and accurate, would preserve in concrete facts and figures the results of expensive experiments so that they could be applied to daily work. In short, what is needed is a metallurgical memory, if we consider that the smelting plant is an organism like a man, following the metaphorical philosophy of Schoepenhauer. Of especial value would such a department be in connection with the department of metallurgical research, which subject we discussed editorially in our July issue. Many thousands of dollars are expended each year at large smelting works in experiments. Most of these naturally are unsuccessful. But these unsuccessful experiments are important, for, as that veteran civil engineer, William J. McAlpine, said, "We learn by our failures rather than by our successes." But in too many instances these are forgotten, especially if the plant suffers a change of regime. In this case, the value of the work is carried to a rival plant, as actually as if the equivalent sum in money was transferred.

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One thing is certain, that engineers who publish as freely as possible in technical journals, put their experience in good shape for themselves and receive suggestions usually more valuable to them than the information they impart. It is an example of growing rich by giving away. But all this valuable knowledge, which Herbert Spencer alluded to in his "Synthetic Philosophy," should be preserved in the manner we have described, for the primary benefit of the owner of that experience. The task is a hard one, for it has been tried and found to be so by more than one concern. But its very difficulty should be an inspiration to some one to combine the qualities of the accountant with those of the engineer and leave in permanent record human thought. We feel sure that this will be the general practice in the future, as it is at present the gratifying exception.



### New York Section Meeting of the American Electrochemical Society at the Electrical Testing Laboratories.

The most successful and enjoyable meeting ever held by the New York Section of the American Electrochemical Society took place on the evening of November 23, at the Electrical Testing Laboratories, 80th Street and East End Avenue, New York City. The attendance reached almost the hundred mark, and proved that in order to attract to the meetings the rank and file of the members it is necessary to offer them something interesting to see. Some of the nearby places, like Perth Amboy, had sent remarkably strong delegations. Not enough credit can be given to the officers of the Electrical Testing Laboratories for the splendid arrangements which they had made and for the indefatigable courtesy with which the visitors were entertained.

The laboratories are situated in the far east of Manhattan Island—so as to be perfectly free from all the disturbances of trolley cars, etc. For this reason some of the members were late in arriving, and it was after 9 o'clock when the chairman of the section, Dr. Charles A. Doremus, called the meeting to order. He introduced the president of the Electrical Testing Laboratories, Mr. J. W. Lieb, Jr., who reviewed the history of the institution. The laboratories were founded with the support of a number of the largest Edison companies in this country, who recognized the necessity of such an institution, not only for their own purposes for testing lamps, but for the electrical industries in general. The main work of the laboratories is still the testing of lamps, not less than 17,000,000 having been tested last year. But the equipment of the laboratories is so complete that almost any electrical tests desired may be easily performed there. Mr. Lieb pointed out that without the aid of the Edison companies it would have been impossible to equip and maintain the laboratory in its splendid condition, but he emphasized forcibly that the laboratories in the testing work are absolutely independent of any commercial relations or of any company.

Dr. Clayton H. Sharp and Mr. W. S. Howell then explained in very interesting speeches the leading principles of the arrangement and management of the laboratory. In order to make the labor cost of testing a minimum, the plan has been followed of laying out all the frequently recurring tests in advance. All requisite apparatus for such tests is put permanently in position and all electrical connections made, so that it is necessary only to connect the material or instrument to be tested into the circuit, close a switch or two and proceed to make measurements. In cases where tests are required less frequently, so that it is not found possible to set apart all the necessary apparatus for their exclusive use, a place has been assigned to the tests, and the electrical connections have been made so that but little preliminary work remains to be done. Mr. Howell then invited the visitors to a thorough inspection of the laboratories, beginning with the top floor and ending in the basement, where refreshments were served.

The chief impression of the visit was the remarkable size of the laboratories—far beyond anything in size and equipment which is ordinarily understood under a laboratory. It is an old electric generating station remodeled for its new purpose. It is a three-story building, 50 x 120 feet, with a two-story addition, 30 x 120 feet. The building is thus amply large for all the requirements of an extensive testing laboratory. Electrical energy is available in any required amount, both in form of direct current and alternating current. Further, with respect to apparatus and instruments, the equipment is so complete that everything that might be needed is at once available. If inventors wish to carry on secret investigations they are at liberty to do so in the rooms on the second floor, which are being rented for such purposes.

There can be no doubt that when the splendid equipment and facilities of the Electrical Testing Laboratories become better known, they will be made much use of for the most varied purposes. For experimental electric furnace work the basement would appear to offer excellent facilities.

The following notes give only a general idea of the arrangement of the laboratory. For more detailed information the reader may be referred to an illustrated pamphlet of Dr. Clayton H. Sharp, which may be had from the Electrical Testing Laboratories, 80th Street and East End Avenue, New York City, for the asking.

The lowest floor, slightly below the level of the street, is concreted and is used as a machinery room. The non-electrical equipment of this room includes a sulphur dioxide refrigerating machine, having a capacity of a ton and a half of ice per day, together with a brine storage tank and a triplex pump for circulating the cold brine through pipes reaching to the top of the building. Besides this there is a motor-driven air-pump, which compresses air in a reservoir from which pipes lead to outlets in many parts of the laboratory. This compressed air is used for operating blast lamps, and is especially useful in removing the dust from articles, particularly delicate electrical apparatus. For executing repair and construction work on apparatus a small but excellent equipment of light machine tools has been installed on this floor. Electrical energy is supplied to this floor from the New York Edison Co., either in the form of direct current at 120-240 volts, or of three-phase alternating currents, 25 cycles 6,600 volts. There are installed also several motor-generator sets and a storage battery. The range of currents at the disposal of the laboratories is very great, particularly since the cables of the Edison system leading to the building are of such size that 500 amps. at 240 volts are available from this source alone. For electrochemical work heavy currents at low voltage are available.

The second floor is devoted principally to the purpose of photometry. It has been said—and this statement is undoubtedly true—that the photometric testing rooms are the finest of their kind in the world, the equipment for making tests of all possible kinds being very complete. On this floor there are also the rooms which are rented to investigators who wish to make secret researches.

The top floor is occupied by offices and contains the laboratory for general electrical testing, the standardizing laboratory for resistance and conductivity tests, instrument tests, high-voltage tests, magnetic tests, etc., etc.

There were quite a number of employees of the Electrical Testing Laboratories present, who, together with the officers of the institution, were indefatigable in courteously showing the visitors around and explaining the equipment. As said before, the occasion was altogether delightful and was greatly enjoyed by all who attended it.

### Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

#### THE AUTUMN MEETING OF THE IRON AND STEEL INSTITUTE.

##### THE SECOND DAY'S PROCEEDINGS.

The only paper which was discussed in any detail on the second day of the Sheffield meeting was that by Mr. Talbot, on "Segregation in Steel Ingots." After referring to the remarks of earlier writers on segregation, the author observed that Pourcel, in 1893, had pointed out that aluminium has a decided tendency to promote segregation, but that no systematic series of tests had been published concerning such results. Mr. Talbot's paper, therefore, contains a record of a series of parallel tests made on ingots from the same heat, with and without the addition of a small amount of aluminium to the ingot.

The ingots taken for examination were from both acid and basic open-hearth furnaces, and varied in weight from about



1½ tons to 3¼ tons, and drillings were taken over the whole surface of the divided ingot.

As a rule, the results show that in the case of ingots to which no aluminium had been added, excessive segregation down the central line of the ingot occurs from about 6 inches from the top to about half-way down the ingot, that sulphur is the element which tends to segregate most, phosphorus next, followed by carbon, and finally manganese, the segregation of which latter element is so slight as to be almost negligible. No silicon determinations were made, as the amount of this element present was extremely small.

An examination of the results obtained shows clearly that by the use of aluminium a billet of a much more regular composition is obtained. This is especially important in the case of carbon, especially if this steel had, without aluminium, been intended for rail purposes, as the surface of the rail would probably have shown considerable irregularities in the carbon percentage, with a consequent want of uniformity in its wearing properties.

In cases in which the carbon has segregated to the center it is obvious that corresponding areas will be found at the sides in which the carbon is less than the mean, through the carbon having migrated to the center to a greater or less extent.

As regards the homogeneity of the steel, Mr. Talbot's analysis tended to confirm Pourcel's view, that the addition of aluminium tended to promote this. His experience on the addition of aluminium in the ingot mould during casting had always been that the aluminium appears to make the metal set quicker. This he was aware was against the view usually held by metallurgists. Thus, in Mr. Harbord's recently published book on steel, it is stated: "The addition of very small amounts of metallic aluminium to such metal"—i. e., metal containing dissolved oxides—"is found to cause a marked increase in the fluidity of the molten metal, to stop the evolution of gas, and to allow of the production of sound ingots without blow-holes."

Not only does the addition of a little aluminium to the metal, as it is run into the ingot, have a marked effect in setting the surface, but it also, in the author's experience, tends, when added above a certain quantity, to form cavities in the upper part of the ingot, so that the amount added has to be strictly regulated. The setting effect on the top of the ingot is so marked that at the works with which the author was connected, after it had become the custom to add aluminium regularly, the ingots were never sanded over or stoppered down, as no such treatment was necessary, either with acid or basic open-hearth steel. With mild steel, also, it was found that the moulds could be stripped sooner when aluminium had been added. It was also observed that when the same quantity of aluminium, viz.: some 3 to 4 ounces per ton of steel was added to the metal as it ran into the ladle, its effect was not so pronounced as when added in the ingot mould as the ingot was being teemed. As to what is the precise action of the aluminium, the opinions of experts differed, some considering that increased fluidity was afforded, others that the reverse action took place. Theoretically, one would undoubtedly expect some increase in temperature, owing to the reaction between the dissolved oxides in the metal and the aluminium, an action akin to the well-known thermit process. If an increased temperature is obtained, with the consequent increased fluidity, this would cause the steel to take longer to solidify, and would consequently tend to increase the segregation, provided that the aluminium has no special action of its own on the metal, whereas the numerous analyses made by the author prove that there is a considerable diminution in the amount of segregation. As the metal appears to set quicker, and as, consequently, segregation would be expected to be less, due to this quicker setting, the analyses seem to agree with this view. The author's usual practice was to add about 3 ounces to 4 ounces of aluminium per ton of steel in the ingot, but this was

never added until the ingot mould was approximately two-thirds full. Assuming the aluminium to be all concentrated in this top third of the ingot, it would then only be at the rate of about 12 ounces per ton, or about 0.033 per cent aluminium.

The author concluded with the suggestion that it would be worth while for other investigators interested in the manufacture of higher carbon steel, such as for rail, tire and similar purposes, to follow up these results, with a view of proving whether a more uniform and regular steel is not thereby obtained, a result well worth the few pence per ton the aluminium would cost. Perhaps the chief result to be looked for would be the decreased amount of crop end that it would be necessary to cut off from the top of the ingot, due to the greater solidity of the top and the lessened amount of segregation in this top part of the ingot. This alone would undoubtedly pay for the cost of the aluminium added, without considering the more regular quality of the finished product as a whole.

A very keen discussion followed, Mr. J. E. Stead being the first speaker. As one who has studied the phenomena of segregation for fifteen years and was still puzzled at some of its manifestations, he had several questions to propound. Why, for example, was there segregation at all? Why did aluminium reduce it? Why was the top of an ingot purer than the rest? It was found that the carbon in the upper layer of an ingot was 18 per cent less than in the center, and sulphur and phosphorus were 30 to 50 per cent less. Why were there less impurities in the top than in other parts? To these questions fairly satisfactory answers could be given. There were a few axioms on the structure of steel to be kept before the mind. First, rapid cooling produced small crystals; secondly, agitation had the same effect; thirdly, the converse was true, slow cooling and stillness resulted in the formation of large crystals. After explaining the growth of "fir tree crystallites" in a cooling mass of steel, Mr. Stead went on to show that the layers first "frozen," those at the top and bottom of the ingot, must be purer than the remainder, hence the diminution of carbon and phosphorus in these parts. The introduction of aluminium had, he thought, the same effect as tranquillity. It prevented circulation and increased the rapidity of cooling, and, by the quietness that it caused, was instrumental in the production of large crystals. Some time ago he (the speaker) made tests of the reputed increased fluidity of steel containing aluminium. Two long spiral moulds of small bore were made. Into one untreated steel was poured. Aluminium was then added to the same ladle, and the other mould poured. On examination it was found that the metal had filled nearly three times as much of the second as of the first mould. But the result was not due to greater fluidity. It was due to the fact that the steel in the first honeycombed, frothed up, cooled and choked the bore; in the second, the flow was solid, it did not cool so rapidly, and hence went further into the mould.

Prof. Harbord was in general agreement with Mr. Stead as to the increased "facility of flow" caused by aluminium, a term that he has adopted in the second edition of his work, and which he considers preferable to "fluidity," and he thought that it was due to a mechanical action of some kind. Mr. Stead had suggested that they should assist segregation. That might do for guns and shafts, but it would not do for rails, and if the introduction of a small quantity of aluminium provided a means of obviating segregation for a few pence per ton, the method should receive the attention of steel makers.

Mr. A. Windsor Richards said that he had found that in those ingots which set most quickly there was least segregation, and therefore they had given up sanding or shattering down. He believed that if steel was properly blown and recarburized it set so quickly that no aluminium was needed to prevent segregation, and he thought the introduction of it would cause piping. He not only agreed with Mr. Stead that segregation was not injurious to rails, but he went so far as to suggest that it might even be an advantage, since the wearing parts were rendered purer by its presence.

After succeeding speakers had ranged themselves for and against the use of aluminium, Mr. Talbot, in reply, urged that the results which he had put before the meeting showed that the addition of aluminium was at any rate worth trying, the quantity necessary being too small to have any effect on the final product.

#### ELECTRIC FURNACES AT THE INTERNATIONAL ELECTRICAL EXHIBITION.

It seems that unwittingly I did this exhibition an injustice in my last letter in stating that there were no electric furnaces exhibited. It was only on a third visit that I came across two of these, exhibited by Messrs. Marryat & Place.

The first, of the Moissan type, consists of a chamber of refractory material; in this case firebrick, having a hole at either end for the carbons carrying the current. The upper half of the box can be removed, showing the carbons lying along their channels with a small space, or hollow, around their tips, so that a crucible may be placed between them. When working, the top box is replaced, and investigation can be made through a spy-hole opposite the arc. The carbons are 2 inches long. The box or furnace measures about 2 feet square. The cavity for the crucible would not be more than about 6 inches x 6 inches x 8 inches deep at the start, but, of course, the sides burn away during the operation; 600 to 800 amps. (alternating) are used.

The second furnace exhibited was of the two-pole Siemens type. The arrangement is similar in appearance to an ordinary well with cross-beam for winding. The "well" is a chamber of firebrick about 1 foot 6 inches square by 2 feet deep. Into this descend the two electrodes, hanging from the cross-bar by screwed rods, provided each with a hand-wheel, so that the distance apart of the electrodes is adjustable. The electrodes are carbon blocks 4 inches x 4 inches x 2 feet long. The method of working is to place scrap in the well, and allow the arc to play in the middle of it; 800 amps. (alternating) is the current employed.

#### A MUNICIPAL ELECTROCHEMICAL UNDERTAKING.

Municipal activities are highly developed in England, the latest departure being the action of the Poplar Borough Council, who are seeking estimates of the cost of a plant wherewith to manufacture their own disinfectants. They propose to employ electrolytically-produced solutions of the hypochlorites, and to use the liquid yielded by the electrolyzer installed for the purpose of washing streets, flushing sewers and for general distribution by the officials of the Local Public Health Department. The use of low-strength solutions is contemplated, the manufactured product to have the low strength of only 2 grammes of available chlorine per liter, and the distributed product one-fourth of this strength. Tenders have been received for the installation of a "Hermite Electrolyseur," using a solution containing 40 per cent of sodium chloride and 10 per cent of magnesium chloride, and producing per hour 250 liters of a strength of 1 gramme per liter. The electrolyzer would require a current of 30 amps. and a potential of 110 volts. To put it mildly, the electrochemical efficiency offered of about 76 grammes per kw-hour would be dear if the apparatus were a gift. In a paper just read before the Faraday Society, there are recorded efficiencies of hypochlorite production at strengths of 3 grammes per liter, which are 350 per cent greater than those mentioned above.

#### PROF. AYRTON ON POWER DISTRIBUTION.

When I referred to the British Association's meeting in South Africa as a picnic, I was better advised in the choice of a word than I then realized. The picnic spirit dominated certain papers, with the result that one past-president of the Institution of Electrical Engineers gave the hall-mark of the past-presidential sanction to the use of the word "enthused" in a paper on a subject of scientific interest. Another, Prof. Ayrton, lectured on power distribution, in a manner most charitably described as "popular." Discarding the excrescences

due to the holiday environment, the professor announced himself as a heretic on the subject of power distribution, and urged the advantages of high-tension direct-current transmission as against alternating currents. A leading article in the *Electrician* hits off the subject very happily in the following words: "The heresy—or shall we not rather say the reactionary movement—is not a new one; it was, like a greater movement, fostered at Oxford, but, strange coincidence, it has thriven most at Geneva." The Geneva allusion is, of course, to M. Thury's experiments between St. Maurice and Lausanne at 23,000 volts.

I need not enter into Prof. Ayrton's specific pleas for continuous-current distribution, but I rather wonder whether his pose as a heretic is that of a mental exercise and recreation or is meant in all seriousness. I may add that on good local evidence the professor does not seriously regard the Victoria Falls as likely to become a second Niagara in regard to electric power distribution. Within the immediate neighborhood of the Victoria Falls there are no possibilities of electrochemical or electrometallurgical industries being established, while the distance to Johannesburg, measured in an absolutely straight line, is 586 miles. Therefore, if electrochemical industries arise in South Africa it is exceedingly probable that, as in England, these can only center around collieries.

#### MARKET QUOTATIONS DURING OCTOBER.

There are one or two small changes to chronicle in regard to chemicals. Arsenic has risen to £14.17.6 per ton, and sulphate of ammonia to £13 per ton. Among the coal tar products carbolic acid crystals have receded ¼d. per pound, but naphtha (crude) has risen from 3d. to 3¼d. per pound, and naphtha solvent from 9½d. to 10½d. Copper sulphate has increased in price to £22.15. Potassium carbonate and caustic potash are unchanged. Shellac is still quoted at £9 per cwt.

Copper closed at £71.5 per ton, a retrogression compared with the price of £72.18.9, which it reached on Oct. 23. Tin fell from £147 to £145.15 per ton on the 9th, the subsequent rise has been a fairly steady one, the closing price being £149.15. Hematite pig iron touched 73s. per ton on Oct. 13, and although now lower at 70s., this price represents a rise for the month of nearly 8s. Cleveland pig iron opened at 51s. 6d., reaching 54s. 6d. by Oct. 18. The price on Oct. 31 was 52s. 9d. Lead is firm in price, fetching £15.5 per ton. Quicksilver is unchanged, at 142s. 6d. to 145s. per flask.

LONDON, Nov. 8, 1905.

## CORRESPONDENCE.

### The Huntington-Heberlein Process.

To the Editor of *Electrochemical and Metallurgical Industry*:

SIR:—With reference to your notes on page 363 of the October issue permit me to express the opinion that you appear to overestimate the chemical effect of the lime-addition in the Huntington-Heberlein process.

In my opinion the characteristic feature of this process is best brought out by its analogy to the Bessemer process. The distinguishing point in the case of roasting lead ores is the easy fusibility of the galena, and the principal object of the addition of lime is to keep the charge open and accessible in all parts to the air blast and to prevent the sintering and melting of galena, which would result in making the air blast ineffective. It, therefore, seems to me that whatever the chemical reactions of the lime may be, its chief function in the Huntington-Heberlein process is not to be found in the chemical effect but rather in a physical one, namely, to keep the charge in the right physical condition for the application of the air blast.

LEAD SMELTER.

[In connection to this subject attention may be called to several articles reviewed in the "Synopsis of Periodical Literature."]

### Electrically-Heated Carbon-Tube Furnaces.

A recent valuable Faraday Society paper, by R. S. Hutton and W. H. Patterson, deals with electric furnaces constructed with a carbon tube through which an electric current is passed. This type of furnace is considered to be the most readily available for the very highest temperatures; despite some inherent disadvantages, due to the presence of carbon, it is capable of very wide application. One of its chief advantages lies in the fact that the temperature can be very easily regulated and kept constant.

Messrs. Hutton and Patterson do not claim any superiority of their types of carbon-tube furnaces over those constructed by other workers. In particular, they state that the construction of some of the furnaces of Dr. H. N. Potter (see our Vol. I., pp. 187, 188, 250; Vol. II., p. 203; Vol. III., p. 14) is obviously more perfect in many of the essential details; although, probably, they could not very easily be made and installed for ordinary laboratory work. Messrs. Hutton and Patterson have been able to get satisfactory results with a very simple type of construction.

#### GENERAL CONSIDERATIONS.

The most important points in the construction of carbon-tube furnaces are, firstly, the provision of a satisfactory device for leading the current to the ends of the tube, and, secondly, the protection of the tube from contact with the air or other material capable of reacting with the carbon to burn it away. It is, moreover, a very great advantage to closely jacket the tube with some substance, which, whilst not tending to combine with the carbon, forms an efficient heat-insulator. Even with the most carefully constructed system of exterior tubes with intermediate gas spaces a great amount of heat is carried away by convection currents in the gases, and consequently much more power has to be expended in the tube to attain any required degree of temperature than when the tube is closely jacketed by some material of low conductivity.

The connections at the ends of the tubes should be so constructed as to remain sufficiently cool to prevent any oxidation of that part of the carbon which is exposed to the air. Moreover, provided the ends are kept cool, it is an easy matter to make a gas-tight joint for the passage of any desired gas through the tube.

#### GRAPHITE TUBE FURNACE.

The first furnaces made by Messrs. Hutton and Patterson were constructed of Acheson graphite, a tube being bored from a solid rod of about 3 centimeters diameter, as shown in Fig. 1. This method of construction is considered to be advantageous when only a few experiments have to be carried out.

The tube is bored, turned from a solid rod, and is screwed

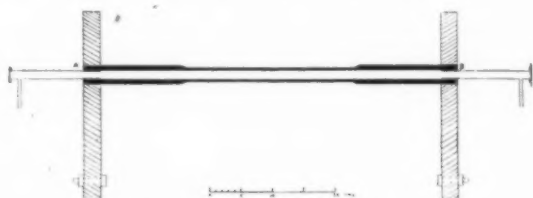


FIG. 1.—GRAPHITE TUBE FURNACE.

at the ends into graphite plates (2.6 by 5.2 centimeters), which are clamped to copper holders (not shown in the figure). The glass extensions, which are fixed into the graphite tube at A and B by asbestos, serve for the passage of gas through the tube; the plate-glass ends enable the progress of the experiment to be observed from either end. The central portion of the tube is surrounded with carborundum, or other heat-insulator, not shown in the figure. The material to be heated is placed in small carbon boats, which are advanced to near the

center of the tube. These boats are so shaped as to touch the tube at only a few points, so that they do not conduct, themselves, any appreciable amount of the current.

As a jacketing material calcined magnesia was not found satisfactory, on account of very great shrinkage. Carborundum is considered to be a very excellent jacketing material. It is a fairly good heat insulator and has the advantage of being a reducing agent, consequently protecting the carbon from burning away. Messrs. Hutton and Patterson used carborundum in a fine granular condition, the grains just passing through a sieve, 180 meshes to the linear inch. As soon as the graphite has attained a fairly high temperature these grains frit together, forming an adherent tube-shaped jacket around the graphite which serves to strengthen and protect it.

#### AGGLOMERATED CARBON-TUBE FURNACE.

For most of their experimental work, Messrs. Hutton and Patterson use agglomerated carbon tubes, which can readily

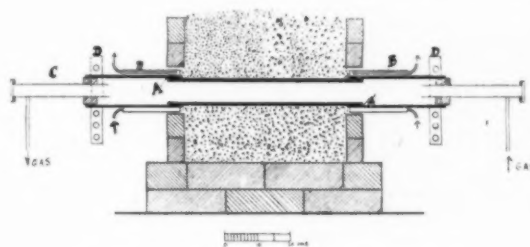


FIG. 2.—AGGLOMERATED CARBON TUBE FURNACE.

be obtained of almost any desired size from manufacturers of arc carbon. The construction, as finally adopted, is spoken of as very excellent in actual use.

The ends of the carbon tube, which may with advantage be somewhat roughened by filing, are electro-coppered, and then soft-soldered to thick copper tubes, just large enough to slip over them. The copper tube is provided for a short distance with a brazed-on water jacket, which effectively cools the joint and protects it, even when a very high current density is necessary; at the further end of the copper tube a copper clamp connected with flexible cables leads in the current. By soft-soldering the carbon to copper tubes with brazed water jackets, it is always possible to easily replace the carbon without any fear of injuring the joints of the water jacket. The length over which the soldered joint has to be made obviously depends on the size of carbon tube and the strength of current to be sent through it, but with this water cooling the necessary surface of contact is surprisingly small.

For the earlier experiments, carbon tubes 30 cms. long, 15 mm. internal, and 20 mm. external diameter, were employed; these were jacketed as before with carborundum, which was generally kept in place with an external asbestos tube and asbestos washers fitting tightly up against the ends of the water jackets.

A similar construction has been used with much larger tubes (60 cms. long, 67 mm. internal, and 82 mm. external diameter), as shown in Fig. 2. The ends of the carbon are coppered and soldered at A and A' to copper tube extensions provided for a short distance with water jackets B, which keep the joint cool. The current is led in by copper clamps D. Glass tubes C are connected to the ends of the copper tubes by rubber stoppers, and serve for the passage of gas and for observation of the progress of the experiment.

With these large tubes it is advisable to use some sort of diaphragm near the ends to prevent the radiated heat from burning the surface of the rubber or cork stoppers, which, as the copper is effectively cooled by the water jacket, can serve to attach the gas inlet and outlet extensions; with the small tubes there is no need to take this precaution.



Owing to the porosity of the carbon tubes at high temperatures, it is difficult, even with a fairly rapid current of hydrogen, to keep the gas in contact with the heated material free from carbon monoxide. Since this was highly desirable in some of the experiments of the author, a modified form of con-

the carbon up to a temperature which remains more or less constant, or at the most only continues to rise very slowly; on the other hand, with carbons closely jacketed with a granular material, which is a good insulator, the temperature continues to rise for a very long time, and in this way, with a much

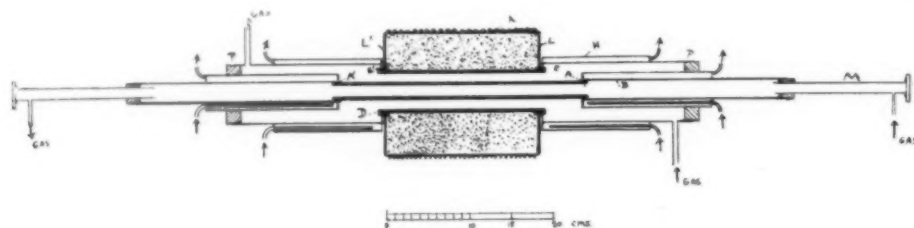


FIG. 3.—SPECIAL FORM OF AGGLOMERATED CARBON TUBE FURNACE.

struction was adopted for this special case. In the first modification the carbon tube was surrounded with a water-cooled, gas-tight metal jacket, through which hydrogen was passed, but with this arrangement the convection currents in the external gas carry off an enormous amount of heat, a very high current density is required to reach even moderately high temperatures. On the other hand, when the carborundum-jacketed tube is, as a whole, surrounded with the gas jacket, the gas in the inner tube still contains 1 or 2 per cent of carbon monoxide, which is probably due to the carborundum containing a small amount of unreduced silica. The arrangement finally adopted (see Fig. 3) has worked well, and is, moreover, considerably more efficient than when a bare carbon tube is surrounded with a large gas enclosure.

The central carbon tube A A' carries the current, and is the heating tube proper; it is provided with copper water-cooled extensions B C, to which the current is led by clamps not shown. To insure the purity of the gas in the tube A A' it is surrounded by a concentric carbon tube E E', which is also provided with copper water-cooled extensions F H, a gas-tight joint between the two tubes being made by the rubber stoppers P. The outer carbon tube is jacketed with a granular heat-insulator to prevent, as far as possible, the radiation of heat. This granular material is held in place by asbestos washers L and an asbestos tube K. Glass extensions M serve as in Fig. 2 for the passage of gas through the heated tube, and for observing the progress of the experiment.

Hydrogen is passed through the space between the two carbon tubes, as also through the inner carbon tube, and in this way it is easy to keep the gas in contact with the heated material almost absolutely free from oxygen compounds.

For a large number of purposes these precautions are quite unnecessary, and the simpler form of construction is all that is required.

The following table gives some of the results obtained by the authors:

Type of Furnace.	Jacketing Material.	Observations.
Graphite; 28 cms. long 2.0 external, 1.5 internal diameter.	Carborundum.	295 amps. at 8.2 volts melts nickel in 26 mins.; 320 amps. at 9.6 volts melts nickel in 13 mins.; platinum in 16½ mins.
Agglomerated carbon; 27 cms. long, 2 cms. external 1.5 cms. internal diameter.	Carborundum.	140 amps. at 7.7 volts melts nickel in 19 mins.; platinum in 28 mins.
Agglomerated carbon; 27 cms. long, 2 cms. external 1.5 cms. internal diameter.	None; bare tube surrounded with hydrogen.	235 amps. at 16.4 volts required to melt nickel (34 mins.)
Agglomerated carbon; dimensions, etc., as Fig. 3.	Carborundum outside outer carbon tube.	200 amps. at 21 volts melt nickel in 3 mins.; current increased to 240 amps. at 25 volts, melting platinum, in further 24 mins.
Agglomerated carbon tube; 60 cms. long 8.2 cms. external, 6.7 cms. internal (as Fig. 2.)	Carborundum.	600 amps. at 8.6 volts give 1,200° C. in 30 mins. (temp. still rising 7° per min.); 850 amps at 13.0 volt melt nickel in 12 mins.; platinum in further 8½ mins.; later much hotter and takes 860 amps. at 11.1 volts.

Important differences manifest themselves according to the type of furnace construction adopted. With a bare tube surrounded with a gas jacket, a given current very soon brings

smaller current and expenditure of power than is required in the previous case, a high temperature can be gradually built up. As the temperature rises, however, the jacketing material becomes an electrical conductor, and even pure oxides at or near their fusing point become good conductors, and by carrying some of the current tend to limit the temperature attainable.

### A Co-operative Analysis of a Copper Slag.

BY THORN SMITH.

(Concluded from page 413.)

The results on lime vary between the highest and lowest to the extent of 1.51 per cent. A discussion as to the causes of the various differences is somewhat difficult. The writer's result was obtained by a double precipitation, after the elimination of manganese, and ignition to oxide. Nos. 5, 12 and 14 agree closely, and two of them at least are by chemists whose complete analyses are far superior to the rest of those coöperating. Nos. 3 and 6 are fair, while Nos. 2, 7, 8, 9 and 10 are not so satisfactory on an element so comparatively simple of estimation. No. 4 is not worthy of consideration.

No. 5 determined the line in the acid filtrate from the silica determination by adding ammonium oxalate and titrating with permanganate. This is the usual rapid method used in smelter practice. No. 12 added ammonium oxalate to a solution free from iron, alumina, zinc, copper and manganese, boiled and allowed to settle. Then filtered and titrated with permanganate. His permanganate was standardized against iron wire of a purity assumed as .996, and also against an oxalic acid solution of known strength. He was able to check his result closely by the same method as used by No. 5.

No. 14 secured his result by a method which the writer has never seen in print. In brief, he weighed 1¼ grams of the slag into a No. 2 beaker, treated with aqua regia until complete solution was effected, then ran to dryness twice, exactly as in a silica determination, took up with dilute HCl and filtered off the silica. The silica was ignited and treated with hydrofluoric acid and the residue added to the main filtrate. This solution was neutralized with ammonia and 3 c. c. of HCl added in excess, after which hydrogen sulphide was run in until the copper was precipitated. The volume of the solution at this point should not exceed 200 c. c. The solution was then filtered into a 250-c. c. flask and well washed with hydrogen sulphide water nearly to the mark. At this point 15 c. c. of strong ammonia was added and hydrogen sulphide again passed for ten minutes. The solution was then made up to 3 c. c. above the mark, to allow for the precipitate, and well shaken. Two hundred c. c. were then filtered off into a beaker and boiled down to a low volume. A little HCl and Br were added at this point to clear up any turbidity. Fifty c. c. of a saturated solution of ammonium oxalate were added to the boiling solution along with

10 c. c. of strong ammonia. The precipitate was allowed to settle for two or three hours and then filtered into a No. 6 beaker followed by thorough washing. The clean precipitate was next dissolved in HCl and reprecipitated. It required much longer standing, and even then a little lime settled out after long standing. This precipitate was titrated against permanganate.

From the result obtained the writer believes this method to be accurate, but not more so than the usual method.

Of the fair results No. 3 precipitated the lime from the alkaline solution after separating the iron, alumina, zinc, copper and manganese in the usual manner. He dissolved the first precipitate, as did No. 14, and reprecipitated. His slightly low result is due probably to the slight loss liable to occur at this point, as mentioned by No. 14. No. 6 made two separations of the iron and alumina and one ammonia oxalate precipitation. He titrated with permanganate, presumably using the same solution as he did in his iron titration. Inasmuch as his result on iron is much too high it would follow that his lime would be correspondingly high. The contrary, however, is the case, and is due in all probability to the lime held up by the iron and alumina, which may be considerable. This point was brought out forcibly by Mr. Rueger in the *Engineering and Mining Journal* of April 28, 1904. Manganese was not removed and would be precipitated in part. No. 2 used a method suggested by the writer. The latter neglected to state that the manganese should be removed before precipitating the lime, hence this high result must, in the absence of other data, be ascribed to this factor. It was hoped that one or more of those cooperating would call attention to this point, but not one did so. No. 7 used the ordinary rapid method. No. 8 used the same method as No. 2, and the criticism of that result will apply. No. 9 failed to state the method used. No. 10 precipitated in the acid solution from the silica determination and titrated with permanganate. Inasmuch as a rapid method does not secure all of the iron and as this chemist's iron is practically correct, it follows that his permanganate solution is weak. Using the same methods Nos. 5 and 10 differ by .6 per cent. The method is the usual rapid smelter control, and gives fair results, if too great haste is not employed.

An accurate determination of lime demands primarily that all of the lime be separated from the iron and alumina. It further demands a second precipitation, and in this the zinc and magnesia are eliminated. If titrated the standard permanganate must be correct. In the absence of this knowledge the lime must be ignited to oxide. Lime is not difficult to estimate, especially when not present in too great quantity, but it does require a strict attention to details and manipulation.

A considerable variation is apparent in the results on magnesia. The standard was secured by two precipitations, previous to which the lime had been twice precipitated. Of the good results Nos. 2, 14 and 15 are beyond criticism, while No. 17 is practically so. Nos. 3, 6 and 8 are not satisfactory. No. 4 found a trace. No. 2 followed the method of the writer and checked exactly. No. 12 may be considered satisfactory, and was made by one precipitation, but previously two separations of lime had been made. The absence of much ammonia salts might perhaps make two precipitations of magnesia unnecessary. It is possible that this chemist lost a trifle by igniting too strongly. Fifteen minutes, as in his case, may cause a loss when the heat is intense. No. 15 followed the method of the writer. No. 14 was secured after throwing out the lime and other bases as previously described at length. This chemist ignited in porcelain, though why is not apparent. However, such does not invalidate his result. Of the unsatisfactory results, No. 3 was obtained by practically the same method as the writer's, and no cause for the low result can be found from a study of other parts of his report. No. 6 obtained his result by one precipitation, preceded by two ammonia separations of iron and alumina and but one for lime. It is evident that in addition to the aforementioned causes

of low results he did not secure a complete precipitation of magnesium phosphate. No. 8 used the same method as the writer. The latter has repeatedly obtained results of this tenor when but one precipitation has been made, and this may be the cause of No. 8's high figures. No. 4 found but a trace. He evidently overlooked the fact that persistent stirring is often necessary, and often a few grains of sodium phosphate must be added in order to start the precipitation.

The chemists of the Association of Official Agricultural Chemists are able to secure closely agreeing results on phosphoric acid which calls for practically the same precipitation. Many of the assistants in the experiment stations are men of very little experience outside their work as students. Hence an accurate determination of magnesia cannot be considered as more than ordinarily difficult.

Manganese is present in this sample of slag to the extent of .37 per cent. When present in such small amounts, in a material of this nature, it does not seem to submit to rapid methods. The determination of manganese is not usually considered difficult, but a glance at the results obtained by the various chemists makes it appear difficult in this case at least. The writer secured his result by precipitation as phosphate after a thorough preliminary separation.

Of the eight results reported but three can be considered as satisfactory. Nos. 12 and 14 agree with that of the writer exactly, while No. 4 has a fair result. The remaining five are not at all satisfactory. No. 12 secured his figures by titration with permanganate after separating the manganese from the basic acetate filtrate with bromine. No. 14 used the same method as the writer. No. 4, whose complete analysis is so exceedingly poor, reports that in his laboratory the separation of manganese by the use of bromine has never been found a decided success, and that often no precipitate at all is formed when manganese is known to be present. This is another remarkable statement, and demonstrates the need of a little study. He precipitated with hydrogen sulphide after taking out the zinc and copper in an acetic acid solution. This method is, of course, accurate if properly performed.

Of the unsatisfactory results No. 2 reports his result as obtained by the method suggested by the writer when the samples were sent out. It consists in weighing the oxide precipitated by bromine. There is, in this method, too much danger of contamination, and while it often gives good results it just as often comes out wrong. No. 3 used exactly the same method, but instead of his result showing contamination it is apparent that at least one-half was lost in the course of its separation. No. 6 used the Volhard method, which was demonstrated in the first report to be unsatisfactory in the case of this slag. It has also since been condemned by the committee on methods of zinc analysis. Poor chemicals is probably the chief cause of failure. No. 8 used the same scheme as Nos. 2 and 3, and evidently did not secure all of the manganese. No. 10 used the same method and jumped to the other side of the standard. The majority of the poor results were obtained by weighing the manganese oxide as secured by precipitation with bromine. One was secured by Volhard's method. Further comment does not seem necessary.

The results on sulphur as a whole are fairly satisfactory. An accurate determination demands that the iron be removed before precipitating with barium chloride. Methods of oxidization may differ, at least in a material of low sulphur content. The writer secured his result by oxidizing with potassium chlorate and nitric acid. A second evaporation with HCl removed the nitric acid. Without taking out the silica a double ammonia separation of iron and alumina was made, and after the addition of a little HCl the sulphur was precipitated by adding barium chloride drop by drop to the boiling solution. This method, particularly the adding of the barium chloride in this manner, is essential to the securing of accurate results. As a check on the above method several determinations were made by the fusion method of oxidization, and

these checked the first given method exactly. Mr. Rueger also checked his result by the fusion method.

Of the results that may be considered satisfactory Nos. 3, 6, 7, 8, 9, 10, 12 and 14 are reported, with Nos. 6 and 8 as the best. No. 6 oxidized with potassium chlorate and nitric acid, but failed to state whether the iron was removed, but it is assumed not. No. 8 used the same method as the writer. He secured one higher result by not throwing out the iron. No. 3 also used the same method. No. 7 used a rapid smelter method. Such methods vary, hence we are at a loss to know how his figure was obtained. No. 9 used the method suggested by the writer. No. 10 oxidized with potassium chlorate and nitric acid, but made only one evaporation to remove the nitric acid. The iron was left in the solution. No. 12 used the method of the writer. No. 14 likewise.

Nos. 2, 4, 11 and 13 are not satisfactory, but No. 13 is not far from some so considered. No. 2 used the same method as the writer, but seems to have failed in some detail. No. 4, while he does not positively so state, probably used the aqua regia method of oxidization. Sulphur in this method is liable to escape oxidization unless the analyst has had considerable experience. No. 11 oxidized with potassium chlorate and nitric acid, but did not remove the iron. No. 13 used the ordinary Colorado practice, whatever that may be. It can readily be seen that the removal of the iron gave the most uniform results. True it is that one or two secured good results without taking this step, but high results are the rule. The subject is a difficult one to discuss, owing to the variable results. The method of precipitating with the barium chloride is of greater importance than is generally considered, and unless strict adherence is held to the standard method, which has been published several times, good results will not be the rule. The determination of sulphur in simple materials should not be considered difficult. It is more of a case where exact adherence to tried methods and manipulations is necessary.

Zinc is the element in which the writer expected to find the greatest variation. A mere glance will show that he was not disappointed. The chief cause of the lack of agreement seems to lie in the use of the Von Shulz and Low method. For accurate work this method is worse than useless, and for even satisfactory results it is doubtful if the method so serves the majority of chemists. It has been the accepted method for so long that the writer's statement may be considered too strong.

A perusal of the results reported to the committee on methods of zinc analysis will soon convince the closest friend of Von Shulz and Low's method what may be expected in everyday work. The estimation of zinc by any method is difficult, owing to the small amount of iron which seems almost impossible to remove. Whether it is estimated as sulphide or carbonate a little iron is almost invariably found with the ignited precipitate, and a correction is difficult. The method of Mr. W. George Waring is said to give accurate results. It consists in precipitating the zinc as sulphide in a formic acid solution and under pressure. This method, in the writer's hands, has failed to give a precipitate free from iron, but this may be due to some defect in his manipulation. However the zinc is finally estimated, Mr. Waring's method is most decidedly the best for a preliminary separation, as it is not necessary to first remove the iron.

Of the ten results reported, Nos. 3, 10 and 13 are the best. Nos. 2, 9, 12 and 14 are fair but hardly satisfactory. Nos. 4, 7 and 8 are very poor. The writer's result was obtained by a preliminary separation of the zinc as sulphide in a formic acid solution, but without the use of a reducing agent other than the hydrogen sulphide employed for the precipitation. No pressure was employed. The zinc was then separated from the copper and lead with hydrochloric acid, the little iron remaining taken out by a basic acetate separation and the zinc finally precipitated as carbonate. The paper containing the moist precipitate was ignited in a platinum crucible at a very low heat until the carbonaceous matter was entirely destroyed, and after

the addition of a few drops of nitric acid and careful drying ignited over the blast for one-half hour. The results were checked by using a porcelain crucible and careful removal of the precipitate from the filter paper. This method is somewhat lengthy, but accuracy was the aim. In view of the writer's success with the samples sent out by the committee on uniformity in zinc analysis, he believes his results correct.

Of the three good results reported, No. 3 precipitated as sulphide and ignited. He checked his result by dissolving this ignited precipitate and reprecipitating as carbonate and ignition to oxide. His preliminary separation of iron and alumina was repeated three times by ammonia. The objection to the use of ammonia is that no matter how many times the separation is made hydrogen sulphide will generally show zinc in the filtrate. No. 10 used the Von Shulz and Low method and secured acceptable results, although a little high. No. 13 used a Colorado method, which means the same as No. 10 probably.

Of the fair results No. 2 made a preliminary separation of the iron and alumina by the acetate method followed by two ammonia separations. The filtrate was then made acid with acetic and the copper and zinc thrown out as sulphides. After separating the copper, the zinc was precipitated as carbonate, ignited to oxide and weighed as such. In view of the fact that his result is high it is probable that a little iron ran through the filter paper in the final acetate separation. No. 12 used practically the same method. His result is low, due, probably, to an incomplete acetate separation. No. 14 used a method differing but little from Von Shulz and Low's. He believes his modification gives accurate results.

Of the very poor results No. 4 was obtained by Von Shulz and Low's method. In view of the fact that this chemist had difficulty with practically the whole of his work it would hardly be fair to lay the blame for poor work on the method used. No. 8 used the same method as did No. 2. It is evident that his zinc precipitate was badly contaminated with iron. It would appear that a majority of those using a gravimetric method did not take the precaution to know that the zinc, or a portion of it, was not retained with the precipitates of the other bases. Not enough results are at hand to criticize the Von Shulz and Low method. The method will undoubtedly receive its share of attention in the reports of the committee on uniformity in zinc analysis.

It was greatly desired in this work to secure information regarding the make, quality and ash content of the various filter papers used, but no satisfactory reports were made.

The writer, on several occasions, has found a so-called high-grade filter paper to be but little better than a very cheap one. Often he has found such paper to contain two and three times the quantity of ash which the makers claim. Such papers may produce an error up to one-tenth of a per cent. The writer believes it a good plan to determine the ash in each new purchase if they are to be used for accurate work.

A question brought up by one correspondent, although not a contributor, is regarding the probable error in sampling and parceling the various samples. This might prove a clever device for excusing a poor analysis were it not for the fact that a majority of chemists are honest. This slag sample was taken by the writer and occupied but a few seconds in the taking. A sample high in copper was purposely chosen. It was mixed in its coarse, granulated condition, then coarsely ground and again mixed by sieving. This grinding, mixing and sieving was repeated until the desired fineness was secured. Consequently, the writer believes that all samples had exactly the same composition. Furthermore, much of his work was done on different samples, as many as five different samples being used on the iron alone.

In concluding this study the conclusion must be drawn that failure to secure satisfactory results, in several instances, is due to incompetence, neglect, over confidence, or all three.

Our methods for the determination of silica and copper have been brought to a high degree of accuracy, and it is not prob-



able that material improvement will be made beyond the use of better glassware and chemicals. The writer has several times stated that the methods of teaching were at fault, and his statement has been abundantly borne out through numerous letters received from his coöperators. A professor of chemistry, whose hobby is organic chemistry, is liable to be a poor teacher of inorganic, and especially of analytical chemistry. Too often he is desirous of following out an interesting derivative, and in such cases his classes in inorganic are taught by inexperienced instructors. The student graduates, and in turn becomes an instructor. While this man's theoretical knowledge may be unquestioned something more is required to make a working analytical chemist. The writer knows of more than one case where exactly this condition of affairs exists and every year it becomes worse. In short, too much is delegated to an instructor whose training is but little above that of the student he is endeavoring to teach. Professors are frequently employed whose chief recommendation is a doctor's degree.

Nothing, in the writer's opinion, is doing more harm to the teaching profession than the indiscriminate publishing of student theses in the leading chemical publications. It makes no difference whether the work is done by a man seeking a master's or a doctor's degree. This applies particularly to applied chemistry. False conclusions, the result of poor analytical work, are often drawn, and these must be reflected to the school from which they emanated. Not only that but such articles are often a source of annoyance to the working chemist who may wish to apply the conclusions. The writer trusts that these remarks will not offend the teaching profession to whom he owes valuable training and inspiration.

Owing to a press of other work the writer is compelled, for the immediate present, to give up this coöperative work, but he looks forward to the time when it can be again taken up and pushed to a point where greater good may come of it.

Ducktown Sulphur Copper & Iron Co., Ltd., Isabella, Tenn.

### The Microstructure of Silicon and Alloys Containing Silicon.\*

By A. B. ALBRO.

(Concluded from page 426.)

#### FERRO-SILICON.

In the steel industries silicon is used in the form of an alloy with iron under the name of ferro-silicon.

With the exception of two samples purchased from Messrs. Eimer & Amend, New York, all ferro-silicons used were made especially for this investigation. In these the silicon content ranged from 30 to 88 per cent, but as ferro-silicon is generally sold under three classifications, viz.: 25 to 30, 50 to 55, and 70 to 75 per cent silicon content, only these grades of the alloy are shown and described herein.

The physical structure of these grades of ferro-silicon is very interesting. As the percentage of silicon increases from 30 to 50 the brittleness of the alloy increases rapidly, and the 50 per cent alloy can be crushed between the fingers to octahedra about  $\frac{1}{2}$  a millimeter on an edge. After 50 per cent is passed the ease of fracture remains practically the same in the vertical plane, but becomes more and more difficult in the horizontal plane. After 75 per cent is passed the fracture becomes more difficult in both planes until the peculiarities noted with 92 to 98.8 per cent silicon are attained.

In the fracture of ferro-silicon containing 60 per cent of silicon, plates were obtained measuring 2 centimeters along their vertical axis, with a width of 1 centimeter and a thickness of from 1 to 2 millimeters.

The etching of the ferro-silicon sections was done by im-

mersing the sample in dilute mixed hydrofluoric and nitric acids for 10 seconds; washing and drying and then immersing in concentrated *aqua regia* until details were brought out clearly.

As a basis of comparison, Fig. 21 shows a practically carbonless area of Swedish iron magnified 118 diameters, with vertical illumination.

Fig. 22 shows 50 per cent ferro-silicon magnified 8 diameters, but does not give the detail presented by this section to the unaided eye, as it then showed distinct laminations running at various angles in different grains.

Fig. 23 is 52 per cent ferro-silicon, 8 diameters, and shows the large grain formation characteristic of silicon. These grains, like those of silicon, are plainly visible to the unaided eye. The incipient fractures can also be seen.

Fig. 24 shows ferro-silicon having 75 per cent silicon content, 8 diameters, and shows the approach to the structure of pure silicon. The matrix seems to be composed of octahedra, with incipient fractures extending in all directions between them.

FIG. 21.—CARBONLESS IRON  $\times 118$ .

No figure is shown of 32 per cent ferro-silicon at 8 diameters, owing to the lack of detail. With a magnification of 34 diameters the details of its structure begin to appear, as is seen in Fig. 25. Irregular areas, surrounded by wide channels which have been etched away, are characteristic of alloys of about this percentage. Continued etching brings out this structure more clearly, but at the expense of flatness of field.

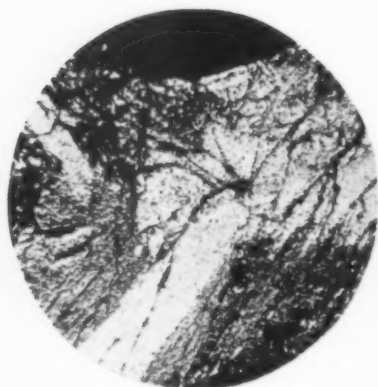
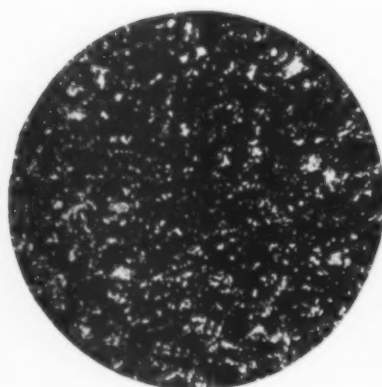
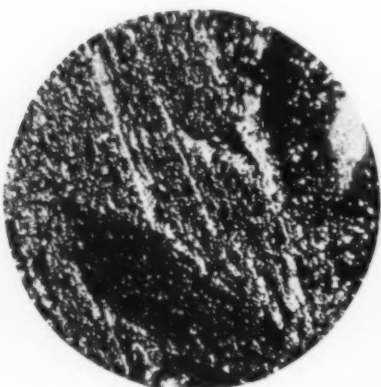
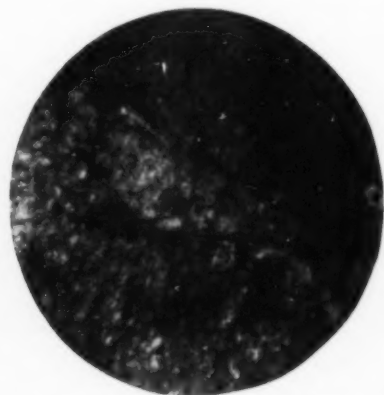
Fifty per cent ferro-silicon, 34 diameters, is shown in Fig. 26. Owing to its extremely pulverulent nature it was impossible to obtain a plane surface for examination, but this figure shows its characteristic crystalline structure, and many octahedra can be distinguished despite the unevenness of the surface and consequent lack of sharpness in the photograph.

FIG. 22.—50 PER CENT FERRO-SILICON  $\times 8$ .

Fig. 27 shows 52 per cent ferro-silicon, 34 diameters. It presents a rough-grained matrix, showing some octahedra and laminae of silicon. These latter show white on the dark background of the matrix.

With the same magnification, 34 diameters, the 75 per cent alloy possesses a very characteristic structure, as is seen in Fig. 28. Numerous irregular-shaped interlocking grains of silicon are seen with the octahedra of the alloy between them and sometimes extending in laminae of considerable length.

\* A paper read before the American Electrochemical Society, Boston meeting.

FIG. 23.—52 PER CENT FERRO-SILICON  $\times 8$ .FIG. 24.—75 PER CENT FERRO-SILICON  $\times 8$ .FIG. 25.—32 PER CENT FERRO-SILICON  $\times 34$ .FIG. 26.—50 PER CENT FERRO-SILICON  $\times 34$ .FIG. 27.—52 PER CENT FERRO-SILICON  $\times 34$ .FIG. 28.—75 PER CENT FERRO-SILICON  $\times 34$ .FIG. 29.—32 PER CENT FERRO-SILICON  $\times 167$ .FIG. 30.—52 PER CENT FERRO-SILICON  $\times 167$ .FIG. 31.—75 PER CENT FERRO-SILICON  $\times 167$ .

With vertical illumination and a magnification of 167 diameters, 32 per cent ferro-silicon exhibits a very interesting structure, as shown in Fig. 29. The etching was carried far enough to bring out the details of the matrix, and, as a result, the irregular prominent grains cannot be brought into focus at the same time. The matrix shows somewhat the structure of impure iron, and seems to have grains of silicon imbedded in it at irregular intervals. The prominent irregular-shaped areas, when brought into focus, show the same structure as that of 52 per cent ferro-silicon with the same magnification, 167 diameters, as shown in Fig. 30.

In this we have the surfaces of two grains and the dividing line between them. The section seems to be homogeneous in

structure, with the exception of one or two large irregular grains standing in clear relief above the surrounding material. These probably are grains of silicon.

Fig. 31 shows 75 per cent ferro-silicon, also 167 diameters. Here we have, in the band running through the center of the field, a structure resembling that shown in the 52 per cent material of the last figure, while the surrounding portions of the field have a structure resembling impure silicon. The fact that the central band is etched slightly deeper than the other portions would tend to prove this.

These figures show that the structure of iron is decidedly different from that of silicon or any silicide of iron which may exist, and that the presence of silicon or a silicide in iron

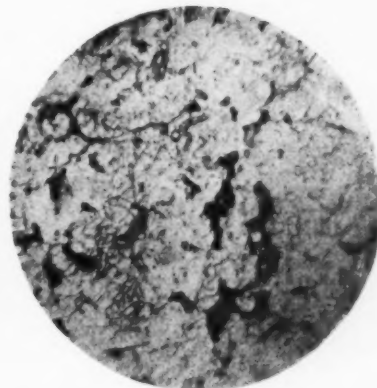
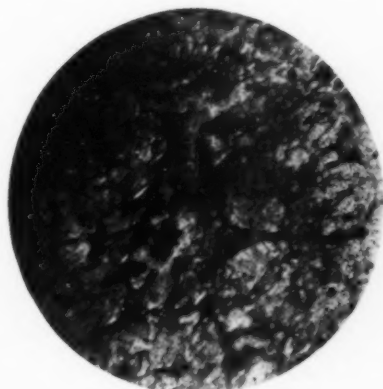
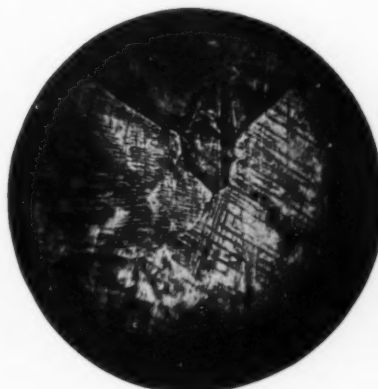
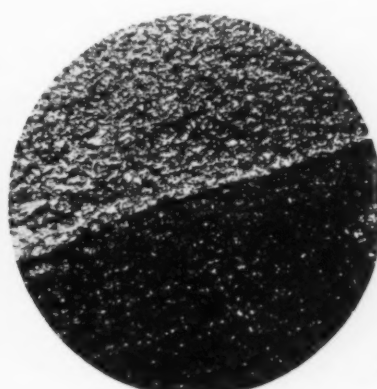
FIG. 32.—Si 2.3 PER CENT, CU 97.7 PER CENT  
X 34.FIG. 33.—Si 10.12 PER CENT, CU 87.0 PER CENT  
X 34.FIG. 34.—Si 10.12 PER CENT, CU 87.0 PER CENT  
V X 167.FIG. 35.—Si 10.12 PER CENT, CU 87.0 PER CENT  
V X 167.FIG. 36.—Si 2.3 PER CENT, CU 97.7 PER CENT  
X 8.

FIG. 37.—(SEE TEXT) X 34.



FIG. 38.—(SEE TEXT) X 34.



FIG. 39.—SiC CRYSTALS X 8.

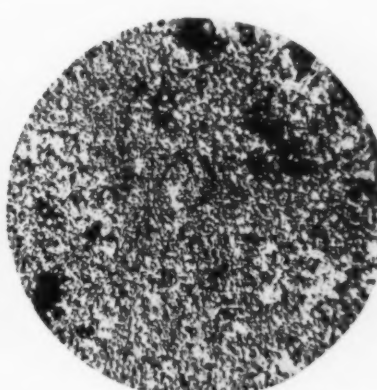


FIG. 40.—Si 80 PER CENT, SiC 20 PER CENT X 8.

should be distinguishable in iron as clearly as that of phosphorus or sulphur. Further, the composition of ferro-silicon can be determined, at least roughly, by means of the microscope with very little practice, and especially when one has only to distinguish between two samples whose silicon content differs by from 5 to 10 per cent. The 30 per cent, 50 per cent, and 75 per cent can readily be distinguished from each other by their fractures.

#### COPPER-SILICON.

In studying this alloy three grades of material were used, containing respectively 2.3 per cent, 10.12 per cent and 23.4

per cent copper. The 10.12 per cent silicon copper was furnished from stock purchased by the Westinghouse Electric & Mfg. Co., while the other two were specially made.

In regard to physical properties these samples differed greatly, the low percentage alloy having almost the same appearance and malleability as ordinary ingot copper, while the high percentage alloy was steel-gray in color, hard and very brittle. The 10.12 per cent alloy possessed properties intermediate between these two, being silver white in color when freshly fractured and turning to a straw-yellow on standing 24 hours. The fracture was markedly conchoidal, and in some



cases in breaking a piece from the mass it would separate with two and sometimes three cleavage surfaces, all of which were conchoidal.

The low percentage alloy was etched with dilute, the other two samples with concentrated *aqua regia*.

Fig. 32 shows 2.3 per cent copper-silicon, magnified 34 diameters after prolonged etching. In the large grains two sets of laminae at right angles are noticeable. In the smaller and darker grain the laminae are at a different angle and somewhat indistinct. The surface appearance of this alloy to the unaided eye was very striking, presenting irregular polyhedral grains, sometimes 2 or 3 millimeters across.

Fig. 33 shows the 10.12 per cent alloy, also 34 diameters. The white areas show the presence of silicon, as they are com-

#### THE ACTION OF SILICON TOWARDS CARBON AND SILICON CARBIDE.

The facts recorded in this division of the subject are presented, because of the peculiar microstructures and physical properties observed.

Silicon may be melted in a carbon container without introducing carbon or silicon carbide. Fig. 37 shows the junction formed between silicon and Acheson graphite under a magnification of 34 diameters. The dividing line is sharply defined, and the silicon is homogeneous in structure, showing no areas in relief, which are always seen when silicon carbide is present.

Fig. 38 shows a cross-section of the tip of an arc electrode used in fusing silicon. In this case the silicon was subjected to a very high temperature, and the carbon to the action of



FIG. 41.—Si 80 PER CENT, SiC 20 PER CENT  
× 34.

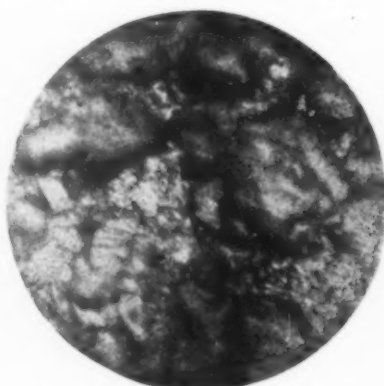


FIG. 42.—Si 80 PER CENT, SiC 20 PER CENT  
× 167.

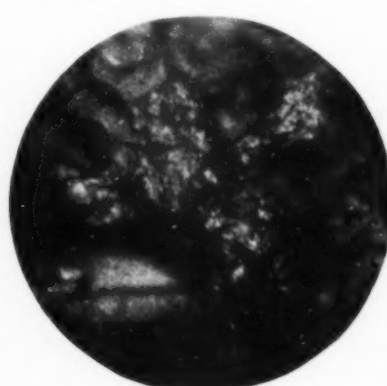


FIG. 43.—Si 80 PER CENT, SiC 20 PER CENT  
× 167.

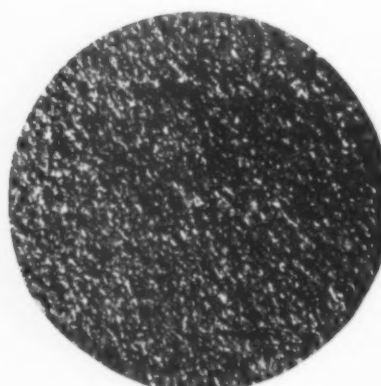


FIG. 44.—CARBOSILICON V × 34.

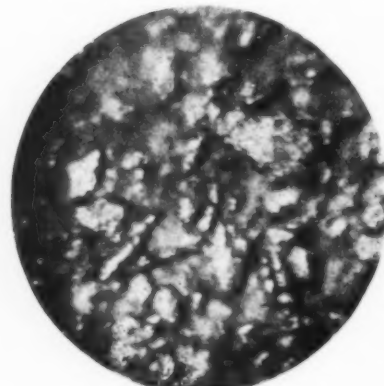


FIG. 45.—CARBOSILICON V × 167.

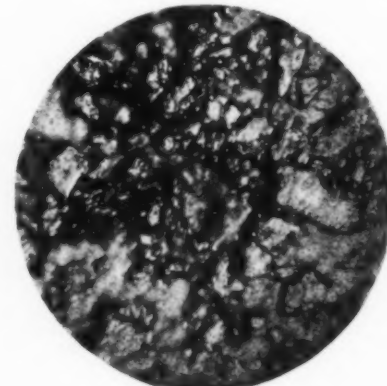


FIG. 46.—CARBOSILICON V × 167.

posed of silica, which results from the action of *aqua regia* on copper silicide,  $\text{Cu}_2\text{Si}$ .

Figs. 34 and 35 show the same sample with vertical illumination and a magnification of 167 diameters. The dark areas are pits caused by the action of the etching fluid, and are, I believe, copper areas. The main body of the section is made up of minute irregular grains overlapping each other to some extent. Some of these are eaten away more rapidly than others, and are a straw-yellow color, while the latter appear white.

The 2.3 per cent alloys, after being repolished and very slightly etched with dilute *aqua regia*, had, when magnified 8 diameters, the appearance shown in Fig. 36. This sample shows some scratches on its surface, but has, nevertheless, the same laminated appearance shown with higher magnification in Fig. 32.

As the high percentage alloy showed nothing in addition to that already shown by the 10.12 per cent copper-silicon, no figures are presented.

The silicon here, in distinction from the former sample, shows the presence of its carbide, as indicated by the long, narrow, raised portions. However, it will be noticed that the dividing line between the graphite and silicon is still sharply defined, but analysis of the silicon shows no free carbon content, and the graphite can be cleanly cut away from the silicon surface. Magnification, 34 diameters.

Solid carbon and molten silicon do not necessarily react. In the large number of samples examined, made under the greatest range of temperatures, the silicon has never contained any free carbon.

The characteristic silicon carbide crystal is described as a hexagonal plate; in other words, a hexagonal prism in which the shortest axis is the distance between the two hexagonal surfaces. With silicon crystals this axis is generally the longest one, and, when crystals of silicon have been found whose form was that of the accepted silicon carbide crystal, they have been called silicon pseudomorphs of silicon carbide,

despite the fact that in the dissociation of the carbide at high temperatures the carbon, not the silicon, remains.

The author has examined many grottoes in silicon in which hexagonal plates have been found, measuring from 2 to 20 millimeters on the longest diagonal. These on analysis were found to be pure silicon, containing no trace of carbon or silicon carbide.

From the powerful influence on the structure of metals in general, it is possible that it profoundly influences the crystal type of its carbide SiC, about 70 per cent of which is silicon, and that hexagonal plates of silicon, instead of being silicon carbide pseudomorphs, are merely another form for the hexagonal prisms or octahedra observed as characteristic of silicon.

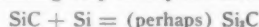
Fig. 39 shows crystalline silicon carbide magnified 8 diameters. The laminated structure is very clearly seen together with several hexagonal plates. This sample consisted of one large crystal, to which several smaller ones were attached.

Silicon containing about 20 per cent of silicon carbide presents the peculiar structure in Fig. 40. The white portions contain amorphous silicon carbide, while the dark areas are silicon. Magnification, 8 diameters.

Fig. 41 shows this same magnified 34 diameters, and reveals a softer matrix from which irregular grains stand out in relief. This structure is shown equally well by polishing in bas-relief on cloth or by etching with mixed nitric and hydrofluoric acids.

The next two slides (Figs. 42 and 43) show different sections of the same sample magnified 167 diameters. The large, prominent grains are a silicon-silicon carbide material; while the hexagonal plates are crystals of carbide which have crystallized from solution of the amorphous material in molten silicon. It will also be noticed that the matrix has the characteristic silicon structure.

In addition to the above reaction, Dr. Potter discovered that when silicon and silicon carbide are saturated with each other the resulting material exhibits remarkable properties. Analysis proves this to contain the element and its carbide in proportions approximating very closely the formula—



The material is non-porous, harder than corundum, and so tough that a 3-inch cube withstood heavy blows from a sledge on all its faces without fracture. It is evident that this substance, termed by its discoverer "carbo-silicon," is very different from either of its components in regard to toughness, and that the method of combining the element and its carbide has much to do with the properties of the resultant substance.

In comparison with the previous figures, which showed a solution of amorphous silicon carbide in silicon, Fig. 44 shows the structure of "carbo-silicon" under a magnification of 34 diameters. It will be seen to be much more homogeneous than the ordinary solution.

The next two figures (Figs. 45 and 46) show this material magnified 167 diameters. All portions of the mass have the same structure as the parts shown in sharp focus in these photographs. No characteristic silicon structure is visible, only that characteristic of silicon saturated with its carbide or vice versa. Its complete freedom from large grains and the absence of any symmetrical arrangement of the grains obviously accounts for its toughness.

It thus appears that silicon has a remarkable influence upon the structure of anything with which it enters into solution or combination, and further investigation would seem almost certain to be rewarded by the discovery of novel and valuable properties which are particularly alluring in view of the certain cheapness of silicon as soon as a demand develops.

These studies were made at the suggestion of Dr. Potter, and I wish in conclusion to express my great indebtedness to him for his direction and counsel throughout.

NOTE.—After the completion of the photomicrographs for

this paper, two samples of ferro-silicon were received from the Roessler & Hasslacher Chemical Co., New York, according to their analysis, containing 57.78 and 75.60 per cent of silicon respectively.

Their appearance, fracture and microstructure are the same as samples of like composition made especially for this paper.

The microstructure of the 75.60 per cent material is characteristic, while that of the 57.78 material shows the distinguishing octahedra of 50 per cent ferro-silicon, with intergranular areas of silicon.

### Metallurgical Calculations.—X.

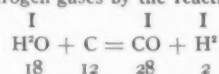
By J. W. RICHARDS, PH. D.

Professor of Metallurgy in Lehigh University.

#### ARTIFICIAL FURNACE GAS. (Continued.)

##### 2. MIXED GAS PRODUCERS.

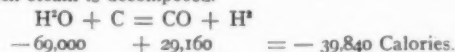
This class of producers are those most commonly used. In them a moderate amount of steam or vapor of water passes with the air into the fire, and is decomposed, producing carbon monoxide and hydrogen gases by the reaction:



which may be read as follows: One volume of steam forms one volume of carbon monoxide and one volume of hydrogen; or eighteen parts by weight of water vapor act upon twelve parts of solid carbon, producing twenty-eight parts of carbon monoxide and two parts of hydrogen. If we speak of kilograms as the above weights, then we can call each "volume" spoken of 22.22 cubic meters; or if we call the weights ounces avoirdupois, each "volume" represents 22.22 cubic feet.

The water vapor is admitted either automatically, as in the old Siemens type of producer, where water was run into the ash pit to be evaporated by the heat radiated from the grate or by hot ashes falling into it, or as in the modern water-seal bottom producer, where the ashes rest upon water in a large pan, and so are continually kept soaked by capillary action; or, finally, steam is positively blown under the grate, either as a simple steam jet or, more economically, by using it in a steam blower, so as to have it produce by injector action an air blast sufficient to run the producer. In the latter case the proportions of air and steam may be regulated with precision, and the blast action produced makes the production and delivery of the gas practically independent of chimney draft. The use of steam also rots or disintegrates the ashes, preventing or breaking up masses of clinker, and so facilitating the removal of the ashes.

Steam or water vapor cools down the fire in the producer, so that it runs cooler; at the same time gas is produced which is rich in hydrogen, and, therefore, of higher calorific power. This saves unnecessary waste of heat in the producer, and increases the efficiency of the gas in the furnace in which it is burnt. The scientific reasons for these facts are to be found in a consideration of the thermochemistry of the reaction by which steam is decomposed.



This would be the deficit in decomposing 18 kilograms of water if it starts in the liquid state. If, however, it is used as steam at 100° C., each kilogram contains 637 Calories of sensible heat, making  $18 \times 637 = 11,466$  Calories altogether, leaving the deficit 28,374 Calories, or the deficit

$$\begin{array}{l} = 1,576 \text{ Calories per kilogram of steam decomposed.} \\ = 2,364 \text{ Calories per kilogram of carbon thus burnt.} \end{array}$$

In making this calculation it might be objected that the steam used is often at three or four atmospheres pressure, and its temperature, therefore, over 100° C.; but it must not be overlooked that this steam expands suddenly to atmospheric

tension, and that in so doing it cools itself to an amount roughly proportional to its excess pressure, so that the expanded steam at atmospheric pressure is usually close to 100° C. When mixed with air, the temperature of the mixture is usually below 100°, some 40° to 50° C., and in this condition some of the steam is possibly condensed to fog, but it must not be forgotten that the heat of condensation thus gives out has been absorbed in raising the temperature of the admixed air, and therefore goes as sensible heat into the bed of burning fuel. For the purpose of calculation, we will, therefore, be very nearly right in assuming that we are dealing in each case with steam at 100° C., requiring the above calculated deficits to be made up, in order for the decomposition to proceed.

It will be evident that any heat thus used in the producer must be sensible heat of the hot carbon, which, if not so used, would be lost as sensible heat in the gases produced or radiated and conducted away from the producer. The basic process of the running of the producer is the burning of carbon to carbon monoxide, liberating 2,430 Calories per kilogram of carbon, which is  $2,430 \div 8,100 = 30$  per cent exactly of the calorific power of the carbon. This heat, if no water vapor gets into the producer, is lost as sensible heat of the hot gases and by radiation and conduction, and is thus largely a dead loss. In Problem 14, for instance, these items figured out 28.25 per cent of the calorific power of the coal used. Now, the facts are, that while small producers need that much heat to keep them up to working temperature, large producers need very much less, and run far too hot if no steam is admitted to check the rise of temperature. In the largest producers the sensible heat in the gases, plus the losses by radiation and conduction, does not exceed 10 per cent of the calorific power of the fuel. Out of the 30 per cent of the calorific power of the carbon inevitably generated, only some 10 per cent is, therefore, needed to supply the losses in a large producer, leaving 20 per cent applicable to decomposing steam. We therefore have:

*Per 1 Kilo. of Carbon Gasified.*

Heat generated .....	2,430	Calories
Necessary loss in a large producer .....	810	"
Useful for decomposing steam .....	1,620	"
Required to decompose 1 kilo. steam at 212° F. (69,000 - 11,466) $\div$ 18 =	3,196	"
Maximum steam decomposable $1,620 \div 3,196 =$	0.507	kilo.

Calculation, therefore, shows that about one-half of a unit weight of steam is the maximum which can be used per unit weight of carbon burnt to carbon monoxide, consistent with keeping the producer at proper working temperature. This would be equal to

- 0.088 kilos. of steam per kilo. of air used.
- 0.088 pounds of steam per pound of air used.
- 0.114 kilos. of steam per cubic meter of air used.
- 0.007 pounds of steam per cubic foot of air used.

The above discussion is on the assumption that the bed of fuel in the producer is thick enough, and its temperature always high enough, to burn all the carbon to carbon monoxide. Such is only an ideal condition, for the irregular charging, descent and working of the fuel always allow of some carbon dioxide being produced, and the best regular gas usually contains 1 to 5 per cent of dioxide, representing some 3 to 20 per cent of the total carbon oxidized in the producer.

Assuming that on an average 10 per cent of the carbon oxidized inevitably forms carbon dioxide, we can calculate under these more usual conditions how much steam can be used, because for each kilogram of carbon oxidized, 0.1 kilo. then gives us 8,100 Calories per kilogram instead of 2,430 in the producer, a surplus of

$$0.1 \times (8,100 - 2,430) = 567 \text{ Calories}$$

over the conditions when only monoxide is formed. Instead of the 1,620 Calories available for decomposing steam we will now have 2,187 Calories, which will decompose

$$\frac{2,187}{3,196}$$

$$= 0.684 \text{ kilo. of steam.}$$

$$3,196$$

Which reckoned on the air used would be

- 0.108 kilos. of steam per kilo. of air used.
- 0.108 pounds of steam per pound of air used.
- 0.140 kilos. of steam per cubic meter of air used.
- 0.009 pounds of steam per cubic foot of air used.

The above proportions are those which cannot practically be exceeded, if producing gas as low as is usually possible in carbon dioxide.

[Working the producer comparatively cold, with excess of steam, much larger proportions of carbon dioxide are formed and correspondingly larger proportions of steam are decomposed, but this manner of working is abnormal, is not unusual, and will be discussed under the next heading, treating of Mond gas.]

Making gas containing any given proportion of CO<sup>2</sup> to CO, by volume, the ratio thus obtained is identical with the proportionate weight of carbon oxidized to CO<sup>2</sup> and CO in the producer, and by the application of the principles just described it can be calculated how much steam can be used per unit of carbon oxidized, making proper allowance for losses by radiation, etc.

*Illustration:* A Siemens producer with chimney draft produced gas containing, by volume, 4.3 per cent CO<sup>2</sup> and 25.6 per cent CO. How much steam could be used per pound of air used, assuming 50 per cent of the heat generated by the oxidation of the carbon to be needed to run the producer?

*Solution:*

Per cent of carbon burnt to CO <sup>2</sup> =	$\frac{4.3}{4.3 + 25.6}$	= 14.4 per cent
Heat generated by C to CO <sup>2</sup> =	$0.144 \times 8,100$	= 1,166 lb. Cal.
Heat generated by C to CO =	$0.856 \times 2,430$	= 2,080 "
Heat generated per kilo. of C		= 3,246 "
Heat lost by radiation, etc. (50 per cent)		= 1,623 "
Heat available for decomposing steam		= 1,623 "
Steam decomposable =	$\frac{1,623}{3,196}$	= 0.508 pounds.

The above is expressed per pound of carbon oxidized, but the same proportion is true per kilogram. The air required per pound of carbon oxidized is found from the oxygen required to form CO and CO<sup>2</sup>:

Oxygen for C to CO <sup>2</sup> =	$0.144 \times 8.3$	= 0.384 lbs.
Oxygen for C to CO =	$0.856 \times 4.3$	= 1.141 "
	6.608	Total = 1.525 "
Volume of air =	$\frac{6.608}{0.0808}$	Air = 6.608 "
		= 81.8 cu. feet
Steam per cubic foot of air =	$\frac{0.508}{81.8}$	= 0.006 lbs.
Steam per pound of air =	$\frac{0.508}{6.608}$	= 0.077 "
Air required per pound of steam		= 13.0 "

It should easily be seen that whatever heat is absorbed in the producer in decomposing steam, is entirely recovered when the hydrogen thus produced is burnt and steam is reproduced. If then, in any case, it is possible to absorb in the producer, in the decomposition of steam, an amount of heat equal to say, 20 per cent of the total calorific power of the fuel, then that 20 per cent is regained and capable of being utilized when the hydrogen so produced is burnt in the furnace. In other words, 20 per cent *less* of the calorific power of the fuel will be lost in the process of conversion into gas in the producer, and 20 per cent *more* will be obtained in the burning of the gas when



it is used. The great advantages of using steam judiciously are thus clearly evident.

### Problem 15.

R. W. Hunt & Co. report the following tests made of the running of a Morgan continuous gas producer. Coal used, "New Kentucky" Illinois coal, run of mine. Composition:

Fixed carbon .....	50.87 per cent
Volatile matter .....	37.32 "
Moisture .....	5.08 "
Ash .....	6.73 "
	100.00

The ultimate composition was:

Total carbon .....	69.72 "
Hydrogen .....	5.60 "
Nitrogen .....	2.00 "
Total sulphur .....	0.94 "
Oxygen .....	11.00 "
Moisture .....	5.08 "
Inorganic residue (less sulphur).....	6.66 "

The ash, on combustion, contains 1.12 per cent of its weight of sulphur (as FeS); the ashes obtained from the producer contain 4.66 per cent of unburnt carbon.

The gas produced, dried, contained by volume:

Carbon monoxide (CO) .....	24.5 per cent
Marsh gas (CH <sub>4</sub> ) .....	3.6 "
Ethylene (C <sub>2</sub> H <sub>4</sub> ) .....	3.2 "
Carbon dioxide (CO <sub>2</sub> ) .....	3.7 "
Hydrogen (H <sub>2</sub> ) .....	17.8 "
Oxygen (O <sub>2</sub> ) .....	0.4 "
Nitrogen (N <sub>2</sub> ) (by difference) .....	46.8 "

[The moisture and sulphur compounds in the gas not having been determined, we can calculate the former, and, for the purposes of calculation, are justified in assuming the sulphur present in the gas as H<sub>2</sub>S, and in subtracting it from the hydrogen. We will also assume that the moisture in the coal goes unchanged into the gases as moisture, and that all the steam used is decomposed. The 0.94 per cent of sulphur in the coal will furnish 0.86 per cent to the gases, because  $6.73 \times 0.0112 = 0.08$  per cent will go into the ash as ferrous sulphide. The 0.86 pound of sulphur would produce 0.91 pounds of H<sub>2</sub>S, equal in volume to 9.56 cubic feet per 100 pounds of coal used, or (since we will see later that 53.83 cubic feet of gas are produced per pound of coal) there will be 0.2 per cent of H<sub>2</sub>S in the gases, leaving 17.6 per cent of hydrogen.]

On the basis of above data and assumptions:

Required: (1) The volume of gas produced per pound of fuel used in the producer.

(2) The weight of steam used per 100 cubic feet of air blown in, assuming the air dry.

(3) The proportion of the total heat generated in the producer which is utilized in decomposing steam.

(4) The percentage of increased economy thus obtained reckoned on the calorific power of the fuel.

(5) The efficiency lost by unburnt carbon in the ashes.

(6) The efficiency of the gas, burnt cold, compared with the coal from which it is made.

Solution: (1) Per pound of coal burnt, there remains in the ashes  $0.0673 \times (0.0466 \div 0.9534) = 0.0033$  pounds of unburnt carbon, leaving  $0.6972 - 0.0033 = 0.6939$  pounds gasified. One cubic foot of gas, at 32° F., contains the following weight of carbon:

C in CO	= $0.245 \times 0.54$ ounces
C in CH <sub>4</sub>	= $0.036 \times 0.54$ "
C in C <sub>2</sub> H <sub>4</sub>	= $0.032 \times 1.08$ "
C in CO <sub>2</sub>	= $0.037 \times 0.54$ "

$$\begin{aligned} \text{Total} &= 0.382 \times 0.54 \text{ "} \\ &= 0.20628 \text{ ounces Av.} \\ &= 0.01289 \text{ pounds Av.} \end{aligned}$$

Gas produced, measured dry, per pound of coal, at 32° F.:

$$\frac{0.6939}{0.01289} = 53.83 \text{ cubic feet.} \quad (1)$$

(2) If the moisture of the coal is assumed to pass unchanged into the gas, as moisture, then all the hydrogen in the dry gas, in any form of combination, must have come either from hydrogen in the coal or in the air blast. The hydrogen in the coal is given as 5.60 per cent. The hydrogen in the gas is calculated as follows, per cubic foot:

$$\begin{aligned} \text{H}^2 \text{ in H}^2 &= 0.176 \times 0.09 \text{ ounces.} \\ \text{H}^2 \text{ in H}^2\text{S} &= 0.002 \times 0.09 \text{ "} \\ \text{H}^2 \text{ in CH}^4 &= 0.036 \times 0.18 \text{ "} \\ \text{H}^2 \text{ in C}^2\text{H}^4 &= 0.032 \times 0.18 \text{ "} \end{aligned}$$

$$\begin{aligned} \text{Total} &= 0.314 \times 0.09 \text{ "} \\ &= 0.02826 \text{ ounces Av.} \\ &= 0.00177 \text{ pounds Av.} \end{aligned}$$

Hydrogen in gas from 1 pound of coal:

$$0.00177 \times 53.83 = 0.0953 \text{ pounds.}$$

Hydrogen from decomposition of steam:

$$0.0953 - 0.0560 = 0.0393 \text{ pounds.}$$

Weight of steam decomposed per pound of coal used:

$$0.0393 \times 9 = 0.3537 \text{ pounds.}$$

To express this weight relatively to the air blown in, we must calculate the air used per pound of coal, as follows:

Nitrogen in gas per cubic foot

$$\begin{aligned} 0.468 \times (14 \times .09) &= 0.5897 \text{ oz. Av.} \\ &= 0.036856 \text{ lbs. Av.} \end{aligned}$$

$$\text{Per pound of coal} = 0.036856 \times 53.83 = 1.9840 \text{ "}$$

$$\text{Subtract N}^2 \text{ in 1 pound of coal} = 0.0200 \text{ "}$$

$$\text{Leaves N}^2 \text{ from air} = 1.9640 \text{ "}$$

$$\begin{aligned} \text{Weight of air} &= 1.9640 \times \frac{13}{10} = 2.5532 \text{ "} \end{aligned}$$

$$\text{Volume of air} = 2.5532 \times 16 \div 1.293 = 31.61 \text{ cu. ft.}$$

Steam used per 100 cubic feet of air blown in:

$$\begin{aligned} &0.3537 \\ &= \frac{0.3537}{31.61} \times 100 = 1.119 \text{ pounds.} \quad (2) \end{aligned}$$

(3) The heat utilized in decomposing steam has been found to be 3,196-pound Calories per pound of steam at 212° F. We, therefore, have the heat so used per pound of fuel used:

$$0.3537 \times 3,196 = 1,130\text{-pound Calories.}$$

This quantity must now be compared with the total heat generated in the producer, and the latter quantity can be determined in two ways: (1) We may subtract from the total calorific power of the coal the calorific power of the gas produced and of the unburnt carbon in the ashes; the difference must be the net heat generated in the producer, i. e., the total heat generated minus that absorbed in decomposing steam. The total heat generated is the net heat thus calculated plus the heat absorbed in decomposing steam. (2) We may calculate the heat of formation of the CO and CO<sub>2</sub> in the gas, and assume that as the total heat generated in the producer. This method is not so accurate as (1).

The total calorific power of the coal is given as practically 7,747-pound Calories per pound, water formed being condensed, which would be decreased by the latent heat of vaporization, if the latter is assumed uncondensed. The deduction is  $606.5 \times [(0.056 \times 9) + 0.0508] = 337\text{-pound Calories, leaving } 7,410\text{-pound Calories as the practical metallurgical calorific power of the fuel.}$

Calorific power of the gas (dried) per cubic foot:

CO	0.245	×	3,062	=	750.2	ounce Cal.
CH <sup>4</sup>	0.036	×	8,598	=	309.5	"
C <sup>2</sup> H <sup>4</sup>	0.032	×	14,480	=	463.4	"
H <sup>2</sup>	0.176	×	2,613	=	459.9	"
H <sup>2</sup> S	0.002	×	5,513	=	11.0	"

$$\begin{aligned} \text{Total} &= 1994.0 \\ &= 124.6 \text{ pound Cal.} \end{aligned}$$

Calorific power of gas per pound of coal:

$$124.6 \times 53.83 = 6,707 \text{ pound Cal.}$$

Calorific power of carbon in ashes:

$$0.0033 \times 8,100 = 27$$

$$\begin{aligned} \text{Sum} &= 6,734 \\ &= 7,410 \end{aligned}$$

$$\text{Net heat lost in conversion} = 676$$

$$\text{Used in decomposing steam} = 1,130$$

$$\text{Gross heat generated in producer} = 1,806$$

Proportion of this utilized in decomposing steam

$$\begin{aligned} \frac{1,130}{1,806} &= 0.626 = 62.6 \text{ per cent.} \end{aligned} \quad (3)$$

(4) We can state this result in another way, by saying that  $1,806 \div 7,410 = 24.40$  per cent of the calorific power of the fuel is generated in the producer, of which  $1,130 \div 7,410 = 15.25$  per cent is utilized to decompose steam, and 9.15 per cent is lost by radiation, conduction and sensible heat in the gases. The calorific power of the gases represents  $6,707 \div 7,410 = 90.50$  per cent of the calorific power of the coal of which 9.15 per cent, however, is clear gain from the employment of steam. Reckoning on the total calorific power of the coal, the increased economy from the use of steam is 9.15 per cent (4).

(5) The loss of calorific power by the unburnt carbon in the ashes is 27-pound Calories, or, on the whole heat available,

$$\begin{aligned} &= \frac{27}{7,410} = 0.36 \text{ per cent.} \end{aligned} \quad (5)$$

This loss is exceptionally low, and may be very profitably compared with the analogous loss of 18.6 per cent occurring in the case discussed in Problem 14.

(6) This has already been calculated as

$$\begin{aligned} &= \frac{6,707}{7,410} = 90.50 \text{ per cent,} \end{aligned}$$

on the assumption that the gases are burnt cold. If they are burnt hot, say issuing from the producer at 1200° F. (649° C.), and are burnt when at 1,000° F. (548° C.) their sensible heat at 1,000° F. will be added to their efficient heating power, and can be calculated with exactness, using the principle explained and used in requirement (6) of Problem 14. Under such conditions the total efficiency of the producer, reckoned on the calorific power of the coal used, approximates 95 per cent.

To be fair to everybody concerned, however, we must deduct from this the coal required to be burnt to raise the steam used. There is a little over one-third pound of steam used per pound of coal used in the producer. This requires in

$$\text{ordinary boiler practice} \quad \frac{1}{3} \times \frac{1}{8} = \frac{1}{24} \text{ pound of coal, or}$$

about 4 per cent of the weight of fuel burnt in the producer. The results of the previous calculation must, therefore, be diminished in this proportion, if the steam has to be raised by burning coal under boilers. Under these conditions (6) becomes

$$90.50 \div 1.04 = 87 \text{ per cent efficiency.} \quad (6)$$

If the steam can be obtained from waste gases of a blast furnace, or from the hot producer gases themselves (in case they are going to be burnt cold), then no such deductions need be made. It is very evident, however, that if 9.15 per cent greater efficiency is gained by burning 4 per cent more coal to raise the steam, that the net gain would be only 5.15 per cent. Even under these conditions it pays to use steam, because of the greater calorific intensity of the richer gas, the usefulness of the steam for supplying air blast, and the rotting of the clinkers therewith obtained.

[The next instalment will discuss Mond gas and water gas.]

### Report of the Karlsruhe Meeting of the German Bunsen Society.

By H. DANNEEL, PH. D., AND J. K. CLEMENT, PH. D.

The following is the continuation of the report, the first part of which was published on page 327 of this volume:

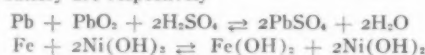
REACTION KINETICS OF THE PROCESS OF ORGANIC CHEMISTRY.

A paper on this subject was presented by Prof. Dr. Goldschmidt, of Christiania. The organic chemist can ascertain analytically only the beginning and end products of a reaction. As to intermediate products he can only set up hypotheses. Information about intermediate products can be obtained from measurements of velocities of reactions.

The well-known formula  $v = A^m B^n$  is often right. When it does not hold it is a proof that the reaction does not take place as was assumed. It has been found, for example, that in the formation of a dye from a diazo compound and an amine, the amine salt does not react itself, but that by hydrolytic dissociation a base is formed, which then reacts with the diazo compound. The author has measured the velocity of the reduction of nitro-compounds to hydroxyl amine compounds by means of stannous oxide. The paper discusses at great length the reactions in alkaline and acid solution.

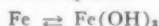
### ACCUMULATORS WITHOUT LEAD.

Prof. Dr. K. Elbs, of Giessen, discussed non-lead accumulators. The reactions in the lead accumulator and in the Edison battery are respectively

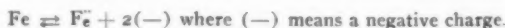


Ordinary Fe when polarized as anode in KOH becomes passive. The active mass of iron must, therefore, be especially prepared. The best way is to glow iron filings in the open air, then reduce them with H<sub>2</sub>, and finally polarize them at the cathode. Fe, which has been prepared in this manner, can be depolarized at the anode fairly well; though it is impossible to make the whole mass of the electrode active. There is always an Fe core which is not acted upon and which does not disappear even after repeated polarization and depolarization.

It is probable that a hydroxide of divalent Fe is formed at the anode. The hydroxides of trivalent Fe could be easily identified by the yellow-brown color, and are not formed until later by oxidation in the air. Furthermore, unless they are subjected to considerable compression in KOH, Fe(OH)<sub>2</sub> and FeO(OH) can scarcely be reduced at all, and Fe<sub>2</sub>O<sub>3</sub> can be reduced only with difficulty. The reaction at the Fe electrode follows the equation

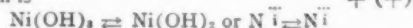


or



The product of the oxidation of Ni(OH)<sub>2</sub> in alkaline solutions is always Ni(OH)<sub>3</sub>. No higher oxide is ever obtained. The product of the reduction of Ni(OH)<sub>3</sub> in operation of the

accumulator is always  $\text{Ni(OH)}_2$ . The equation for the reaction is



The complete equation is



The process of charging and discharging the positive plates is more complete than that of the negative plates, though even on the positive plates, with moderate current density  $\text{O}_2$  is evolved. Both of the nickel hydroxides are only very slightly soluble in KOH. The hydroxides of cobalt are quite soluble in KOH, and cobalt is, therefore, unsuitable for use in the accumulator.

The e. m. f. of the combination Fe, KOH,  $\text{Ni(OH)}_2$  is 1.42 to 1.48 volts when the accumulator is freshly charged. While

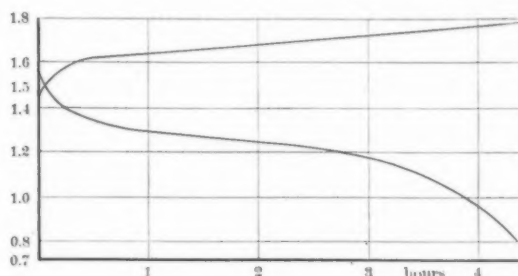


FIG. 1.—CHARGE AND DISCHARGE CURVES OF Ni-Fe CELL.

standing, the e. m. f. falls slowly on discharging rapidly to 1.35 or 1.37. It is independent of the concentration of KOH.

Dr. Gräfenberg, of Kalk (near Cologne), spoke on the Junger battery, as made by a German storage battery company. (This is essentially the same as the Edison battery.) The positive electrode is made of black nickel hydrate. A hydrate of the lower oxide is obtained electrolytically and is converted to the higher oxide by chemical oxidation. The negative electrode is composed of iron, which is obtained by the reduction of iron scales by  $\text{H}_2$  at  $380^\circ$ . To the nickel oxide 40 per cent nickeled graphite is added and to the iron 10 per cent.

These masses are then compressed into small bricks, which are introduced into boxes of thin sheet nickel and further compressed. Ten such boxes are formed into one plate.

The speaker exhibited an accumulator consisting of six pairs of plates in a pressed steel case, the total weight of which was 3 kilograms. The distribution of weight is active mass, in-

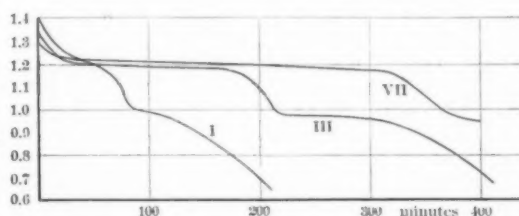


FIG. 2.—DISCHARGE CURVES OF Fe ELECTRODE.

cluding admixtures 900 grams, frames of plates 750 grams, electrolyte 625 grams, case, etc., 725 grams.

The electrolyte is 20 per cent potassium hydroxide, which is free from acid radicals, organic substances and carbonic acid.

With a normal discharge of 4 hours the cell has a capacity of 35 to 40 ampere-hours, with an average e. m. f. of 1.23 volts. That is 16 to 18 watt-hours per kilogram of aggregate weight. The volume is 2.9 liters per 100 watt-hours.

The resistance increases during the discharge. The average value for the small cell was 0.0035 ohm.

The e. m. f. of the cell at rest is 1.35 volts. On charging it rises rapidly to 1.6 and then gradually to 1.68. Fig. 1 shows the curves for the whole battery. The potential curve of the Fe electrode (Fig. 2) shows two distinct stages of discharge, one at 1.2 volts and the other at 0.9 volts. The formation of the active material of the Fe electrode is complete after seven charges.

Fig. 3 shows that the Ni electrode has only one stage of discharge. The Ni electrode reaches its full capacity in five discharges. Theoretically, the iron electrode has the greater capacity, but the efficiency of the reaction at the Ni electrode is 75 per cent, while that of the Fe electrode is only 10 per cent.

The capacity decreases only slightly with increasing current density. The accumulator will be useful principally where heavy currents are required.

The iron electrode is affected by the air, so it is difficult to transport it. When charged it oxidizes, when discharged it is further oxidized to ferric oxide, and is afterwards difficult to reduce. The accumulator is very insensitive to rough handling, and is not easily injured while in transportation. After 100 discharges it had lost 12 per cent of its efficiency, after 200 discharges 17 per cent. This loss has not yet been explained.

In the discussion, Dr. Roloff said that Elb's equation is correct, but there are other reactions which take place. This is

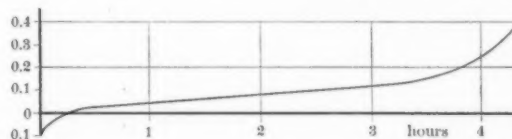


FIG. 3.—POTENTIAL CURVE OF Ni ELECTRODE.

proved by the step-shaped fall of the e. m. f. of both electrodes. There are also several stages in the charge. By measuring the potentials against an Hg electrode, Roloff identified the electrode potentials as potentials of the various oxides of Ni and Fe. He found a black  $\text{Ni(OH)}_2$ , which was previously unknown. Its formula is  $\text{Ni(OH)}_2 + 2\text{H}_2\text{O}$ . The hydrate  $\text{Ni(OH)}_2 + \text{H}_2\text{O}$  is gray. Anhydrous  $\text{Ni(OH)}_2$  is green.

#### THE ACTION OF THE PHARMACEUTICAL REAGENTS ON LIVING ORGANISMS.

A paper on this subject was presented by Prof. Dreser, of Elberfeld, who studied the effect of increasing quantities of salicylate of soda on the evolution of  $\text{CO}_2$  from barm. An interesting result is the experimental and mathematical demonstration of the homeopathic doctrine that small doses of poison are invigorating, while large ones are fatal.

#### KINETICS OF EXTREME STATES OF MATTER.

Dr. Emil Bose, of Göttingen, presented a paper, an interesting result of which is that through kinetic considerations on rarified gases conjointly with the electron theory, an advance into the uninvestigated field of the kinetic theory of solid substances is made possible. From experimental results obtained for quartz, fluorspar, sylvite and rocksalt, the author concludes that the amplitudes of the molecules in the solid state are considerably smaller than the mean distance between molecules.

They also indicate a parallelism between the coefficient of expansion and amplitude of oscillation.

#### SUGAR SYNTHESIS; SILENT DISCHARGES.

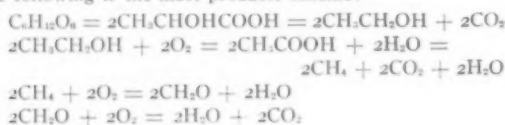
Dr. W. Löb, of Bonn, presented a paper on the assimilation of carbonic acid. It is unfortunate that this paper, which is perhaps the most interesting of the whole congress, cannot be reviewed as completely as the importance of the subject



demands. The author has imitated in laboratory experiments the formation of sugar from carbonic acid and water, as it occurs in plants.

He followed, in the opposite direction, the same course which nature takes in the breaking down of sugar molecules by fermentation. He first reviewed exhaustively the literature on the subject and the various hypotheses which have been set up.

The following is the most probable scheme:



The final result is:

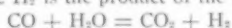


The speaker enumerated the facts which lead to this scheme and described the method with which he obtained his sugar synthesis.

Carbonic acid and water, under the influence of the silent electric discharge, form carbon monoxide, CO, and a small amount of formic acid, HCOOH. If oxygen is excluded from the CO, formaldehyde is formed:

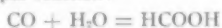


The  $\text{H}_2$  is the product of the reaction:



which always takes place in a mixture of CO and  $\text{H}_2\text{O}$  vapor at high temperatures.

At the same time formic acid is formed. Its production is considerably increased by adding  $\text{H}_2$  to the gas mixture. It is probable that in plants the formation of formic acid is the principal reaction:



since formaldehyde is never found in plants. If a depolarizer which will remove oxygen, *e. g.*, benzaldehyde, salicylic acid, even chlorophyll is added, the production of CO and HCOOH becomes much greater. Part of the formaldehyde unites with water vapor to reform  $\text{CO} + \text{H}_2$ . At the same time methane is formed:



Formic acid and water vapor act similarly. Methan and water form acetic acid. Since  $\text{CH}_4 + \text{CO}$  gives acetaldehyde, the formation of acetic acid is similar to that of formic acid.

It is known that ethyl alcohol is formed from acetic acid by reduction; perhaps alcohol is formed directly from aldehyde and methane. On the other hand, it is known that alcohol is the regular product of the fermentation of sugar, and it is frequently found in plants. The experiments on the formation of alcohol are not yet completed. Alcohol and water alone do not form hydrocarbons. Hydrocarbons are obtained, however, when the silent discharge is passed through  $\text{CH}_3\text{COOH} + \text{H}_2\text{O} + \text{CO}_2$ . The speaker obtained a liquid which gave all the reactions of a sugar, in particular of a hexose. After evaporating, there remained an acid (due to lactic acid?), syrupy liquid, whose reactions were described in detail by the speaker. With phenylhydrazine he obtained an osazon whose melting point was  $148^\circ$  to  $155^\circ$ —perhaps  $\beta$ -acrose.

It is probable that the way in which the sugar synthesis takes place varies in detail according to the nature of the different plants. So much is certain that the addition of energy alone is sufficient to carry out the synthesis of sugar from  $\text{CO}_2 + \text{H}_2\text{O}$ .

The speaker closed with some interesting remarks concerning assimilation in plants. Chlorophyll alone is not capable of producing the sugar synthesis—in addition a supply of energy (mostly in the form of light) is required. Chlorophyll probably serves only to remove the oxygen—this is necessary to produce a good yield.

#### FIXATION OF ATMOSPHERIC NITROGEN BY ELECTRIC DISCHARGE.

Dr. Johannes Brode spoke on the oxidation of nitrogen in the high-tension electric arc. When high-tension electricity is discharged in the air with a current of about 0.1 amp., an arc, having three zones, is formed: I., a brightly luminous, bluish band arched upwards; II., above that a bluish-green part; III., a dim brownish layer, bending upwards. The appearance of the arc is independent of the material composing the electrode. It is, therefore, not due to small particles broken off from the electrodes.

The arc varies only slightly when the current is varied. When the distance between the electrodes is increased, part III. becomes larger.

In air and in nitric oxide the same reaction takes place, but in opposite directions, *i. e.*, equilibrium sets in. The equilibrium depends on the number of watts used, on the kind of current, the distance apart of the electrodes, and, when the electrodes are close, on the material of the electrodes and the cooling of the electrodes. In the hot part of the arc a higher concentration of nitric oxide is formed; in the cooler part it is partly decomposed.

The speaker showed that the flow of current is principally in Part I. When a glass rod is introduced into Parts II. and III., current and voltage remain unchanged. But when it is held in Part I. the voltage changes. Part I. has, therefore, the highest temperature.

From the Van't Hoff equation, Nernst calculated the curve NO — concentration — temperature. The author found that in zone I. a gas mixture containing 8 vol. per cent NO is formed, from which a temperature of  $3,700^\circ$  is calculated. In Part III. the concentration of NO in equilibrium with  $\text{N}_2 + \text{O}_2$  is less. Therefore, when the NO formed in Part I. enters Part III. it is partly decomposed. Zone II. could not be investigated.

The speaker described other experiments in which he found that ozone is formed in oxygen by the heat of the electric arc. He found no indication that  $\text{O}_3$  is formed by the light rays of the arc.

When the arc is broken up by a magnet or other means, the cooling is more rapid, and the loss of NO is small. This fact is known to industrial electrochemists.

#### ZINC AND MANGANESE AS ANODES.

Dr. W. J. Müller, of Mühlhausen, spoke of the anodic behavior of zinc and manganese. The author used anodes with different current densities and measured their potentials against a normal electrode. The capillary syphon which lead to the normal electrode was introduced in immediate proximity to the electrode.

In NaOH the polarization of zinc is normal, *i. e.*, the same potential curve is obtained with rising as with falling current density. The same is true of zinc in neutral and acid solutions of  $\text{Na}_2\text{SO}_4$ .

In alkaline  $\text{Na}_2\text{SO}_4$  solutions the result is quite different. In a solution of  $n = \text{Na}_2\text{SO}_4$  and 0.5*n* NaOH the polarization rose normally at first. At 4 to 6 milliamperes there is an enormous falling off of the potential; on increasing the current density beyond this point the polarization rises further in a straight line, and is accompanied by the evolution of gas. With decreasing current density the polarization falls in a straight line to 0.9 milliamperes, at 0.7 milliamperes the polarization reverts momentarily to its initial value.

The following general results were obtained: First, the polarization of Mn and Zn is normal in all acid solutions of sodium sulphate and sodium phosphate and in neutral sulphate solutions; the polarization of Zn is normal in neutral phosphate solutions. Both metals polarize normally in solutions in which concentration of NaOH is less than 0.01 normal.

Secondly, with abnormal polarization there are two distinct cases: either the *e. m. f.* sets in at once as with Zn in alkaline sulphate solutions, or the abnormal polarization requires a cer-

tain length of time to develop, as with Zn in alkaline solutions of phosphate, and with Mn in all alkaline solutions.

Thirdly, with normal polarization the metal always goes into solution with its smallest valency. In cases where the polarization is abnormal one would infer that the metal changes into a passive modification. The author could detect no change in the reflecting power of a zinc mirror which had been subjected to anodic electrolytic action.

If a passive layer were formed its passivity would continue for some time, but such is not the case. The author used his experiments to support a theory of passivity which he had advanced previously.

#### CONTACT PROCESS OF MAKING SULPHURIC ACID.

Prof. Dr. Max Bodenstein dealt with the determination of equilibrium in contact sulphuric acid. This subject, which was first investigated in the classical paper of Knietzsch, is important to both scientific and technical chemistry.

Though it has been the subject of a number of thorough experimental investigations, the results of the various experimenters are in part quite different. This is due to the unusually great experimental difficulties to be encountered.

From his experiments at 500°, the working temperature of the Baden Anilin & Soda Factory, at which the equilibrium is close to 100 per cent SO<sub>3</sub>, Knietzsch concluded that the law of chemical mass action is of no importance in technical chemistry. This is certainly not true for higher temperatures, such as are required when ferric oxide is used as the contact substance.

The author determined, therefore, the constant of equilibrium, K of the reaction:  $2\text{SO}_2 + \text{O}_2 = 2\text{SO}_3$

$$K = \frac{[\text{SO}_2]^2 \times [\text{O}_2]}{[\text{SO}_3]^2}$$

in which the symbols in brackets denote the pressures of the gases in question.

The measurements were made at different temperatures and were very exact. His ingeniously designed apparatus avoids the sources of error inherent in previous experiments, especially the uncertainty of the temperature.

The gas (SO<sub>2</sub> distilling at room temperature and electrolytic O<sub>2</sub>) having been previously analyzed, was passed through a quartz vessel, which was filled with platinum sponge.

The quartz vessel, which was held in a modified Heraeus platinum foil furnace, was composed of two compartments. From these the gas passed very rapidly through a fine capillary tube, thus avoiding any appreciable displacement of the equilibrium by the fall of temperature.

The form of the quartz vessel made it possible to obtain the equilibrium from opposite direction also ( $2\text{SO}_3 \rightarrow 2\text{SO}_2 + \text{O}_2$ ).

Measurements made at 727°, under the most varied conditions of experiment, proved that the constant of equilibrium obtained is independent of the direction of the reaction (*i. e.*, whether the reaction proceeds from SO<sub>2</sub> or from SO<sub>2</sub> + O<sub>2</sub>), independent of the velocity of the flow of gas, of the relation of SO<sub>2</sub> to O<sub>2</sub> in the original gas mixture, and independent of the presence of nitrogen.

The experiments furnish a verification of the law of chemical mass action which for range and accuracy has been equalled probably by no other reaction. The results of the experiments are:

Temperature C°					
528	627	727	832	897	
K $1.55 \times 10^{-3}$	$3.16 \times 10^{-3}$	$3.54 \times 10^{-3}$	$2.80 \times 10^{-3}$	$8.16 \times 10^{-3}$	

Temperature	500°	600°	600°	700°	700°	800°
q	21,900		21,700			21,500

From these figures the following values for q, the heat of reaction of the Van't Hoff formula, were calculated:

Temperature	500°	600°	600°	700°	700°	800°
q	21,900		21,700			21,500

The value of q at room temperature is found by extrapolation

to be 23,100, which is in excellent agreement with the value obtained by Berthelot, 22,600. For the specific heat of SO<sub>2</sub> at 100° C. 10.6 was obtained. This result accords with the values for other similar gases.

The formation of sulphuric acid fulfills the requirements of the law of chemical mass action so completely that it forms one of the most instructive examples of the application of the law. The constant K can be calculated from the equation (T = absolute temperature):

$$\log K = -\frac{10373}{T} - 2.222 \log T + 14.585$$

in close approximation to the observed values. The author exhibited tables and curves from which the yield at different temperatures and with gases of different compositions could be read off directly.

The conclusion of the report will be published in our next issue.

#### Faraday Society Meeting.

The sixteenth ordinary meeting of the Faraday Society was held on Oct. 31, the president, Lord Kelvin, being in the chair.

##### ALTERNATING-CURRENT ELECTROLYSIS.

Prof Ernest Wilson gave a resumé of his paper on alternating-current electrolysis. Experiments made with platinum plates in dilute sulphuric acid show that of the total energy supplied to the cell in a given time, more is returned to the source when the frequency is high than when it is low—the maximum coulombs being of the order .0006 per sq. cm. in each case. If the quantity of electricity be plotted co-ordinately with the e. m. f. of electrolysis it is found that at the higher frequency, for about the same maximum coulombs, the curve has relatively a smaller area, such reduction being probably brought about by the greater reversibility. An experiment made at an intermediate frequency when the maximum coulombs were .000023 per sq. cm. gave a still higher value for the proportion of the total energy which is returned to the source—demonstrating that the magnitude of the maximum coulombs has an important effect.

Further experiments made with aluminium plates in dilute potash, soda and ammonia-alum solution showed a similar effect.

Judging from the above experiments, one might be led to expect that when a metal is dissolved in an electrolyte by alternate-current electrolysis, the amount dissolved in a given time at a given current density would be smaller at high than at low frequency. This is found to be the case.

Besides this chief conclusion there remain indications of other important effects. So great is the number of variables, and so great the difficulty of keeping all but one constant during an experiment, that from the few experiments performed it is dangerous to attempt a generalization.

A series of experiments was made to determine the influence of current density, the frequency being constant = 92. The weight of lead dissolved in dilute H<sub>2</sub>SO<sub>4</sub> increases with the current density. Amalgamated zinc is difficult to deal with as the degree of amalgamation influences the result. Iron is dissolved in ferrous-sulphate at a greater rate the greater the current density when the respective experiments are started with fresh solutions. This is not the case when a new experiment is started in a solution whose density has been increased by electrolytic action in a previous experiment. A difficulty with ferrous-sulphate solution is its known tendency to oxidize. In sodium chloride more iron is dissolved at the higher current density. A complete investigation would need to take accounts of the density and temperature of the electrolyte, and possibly of other conditions.

Mr. W. R. Cooper then presented an abstract of his paper on

alternating-current electrolysis, as shown by oscillograph records. The author pointed out that although polarization is of the nature of a capacity in an alternate-current circuit, there is a considerable difference. What might be termed the e. m. f. of a condenser rises and falls as rapidly as the applied pressure, but although the e. m. f. of polarization may rise as rapidly as the applied pressure, it falls more slowly, with the result that under suitable conditions the current curve may depart very considerably from the sine form. Actual oscillograph records were reproduced in support of this view. In considering the subject it has been very generally assumed that the current follows a sine curve. Since the curve obtained depends very much on the conditions of the experiment, it is necessary to define the conditions very carefully before conclusions can be drawn from different experiments. Oscillograph records of electrolytic rectification were also shown.

In the discussion which followed, Mr. A. E. Trotter referred to the bearing of work on alternate-current electrolysis on the corrosion of water and gas pipes, caused by stray currents from alternate-current systems. He described some practical experiments he had made with lead pipes buried in the earth; these experiments showed that there was a minimum current density or a minimum voltage—he was not sure which—below which no corrosion took place. More work was required to be done in order to indicate the exact conditions necessary for corrosion, but great caution was necessary in the application of scientific experiments to practice.

Mr. James Swinburne thought that the greater absorption of energy found by Prof. Wilson at the lower frequencies was simply due to diffusion, and this was borne out by Mr. Cooper's curves.

Dr. F. M. Perkin said he had found that platinum plates electrolyzed alternately in dilute sulphuric acid were more corroded at low than at high frequencies; a colloidal solution of platinum seemed to form, and the electrodes had an etched appearance.

#### CRYSTALLINE STRUCTURE OF ELECTRODEPOSITED COPPER.

Prof. A. K. Huntington presented a paper on this subject, which was illustrated by microphotographs.

In Mr. Cowper-Cole's process for making copper wire electrolytically (see our October issue, p. 392) a spiral scratch or groove on the mandril causes the copper deposited on it to part so easily that a long ribbon can be obtained. The author's explanation is that the direction of the lines of crystallization of an electrodeposited metal are the same as in a casting made on surfaces having the same inclination, i. e., the crystals form at right angles to the surface on which the deposit or the casting is made. It follows that when the crystals which form on surfaces more or less at an angle to one another meet, there will be want of continuity in the two sets of crystals, and a

line of weakness will be developed. Therefore, in castings and deposits when strength and not rupture is aimed at, it is important to avoid sharp angles.

In the case of a cathode plate which has been deposited on a thin strip of electrodeposited copper the crystals of the original strip continued in some cases in the cathode plate. On annealing the electrodeposited copper the long crystals of the deposit are completely broken up and become largely twinned. Hence brittleness, due to the direction in which crystals form in castings and electrodeposits, may be modified and probably completely removed by suitable annealing, unless the continuity is entirely broken.

In the discussion which followed, Mr. J. F. R. Rhodin thought that structure of the copper deposited in a groove, such as Mr. Cowper-Coles employed, depended on electrostatic repulsion rather than on crystalline form. The fringing at the edge of a deposit, even where the current density was not high, seemed to him to confirm that explanation.

#### ELECTROLYTIC PRODUCTION OF HYPOCHLORITE.

A paper by Mr. W. Pollard Digby dealt with some observations respecting the relation of stability to electrochemical efficiency in hypochlorite production.

The author commenced by drawing attention to the fact that in all electrolytic methods of producing hypochlorite solutions, only a small portion, rarely more than 18 per cent, of the chlorine usually present in the form of chloride is converted into hypochlorite, and suggests that the amount of available chlorine produced from a sodium chloride solution depends upon the relation which the amount of unconverted sodium chloride actually present between the electrodes bears to the current density.

As regards stability, particulars are given of two tests in which the rate of depreciation, although only 0.3 to 0.4 grammes in 12 hours per liter for solutions containing 8 grammes of available chlorine per liter, caused a very great depreciation in the yield per kw-hour supplied. The suggestion is advanced that no test of the efficiency of any apparatus for the electrolytic production of the hypochlorites can be regarded as complete without an estimation of the losses through instability, and a mention of the volume of the contents of the electrolyzing tank.

While stability of solution does not greatly affect the efficiency of any continuous type of apparatus (in which the sodium chloride is fed in at one end and drawn off at the other end ready for continuous use), it will materially affect the efficiency in any non-continuous apparatus, or in any apparatus in which the electrolyte is circulated through an external cooling tank and returned to the electrolyzer to be further worked up. It is suggested that the presence of minute quantities of iron in the solution have also a bearing on the depreciation.

## ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS

### ELECTRIC FURNACES.

**Reducing Oxides.**—A. J. Rossi, 802,941. Oct. 24. Application filed Nov. 3, 1902.

To reduce highly refractory oxides, as that of titanium, the inventor uses aluminium as reducing agent with heat supplied from an outside source, preferably—if very high temperatures are required—in form of electrical energy. In the latter case he obtains the heat of the electric furnace combined with the heat evolved by the oxidation of the aluminium. First a fused bath of aluminium is produced, into which the metallic oxide is then introduced, not necessarily in powdered form, but merely in their natural condition, or such coarse sub-division as will tend

to accelerate the reduction to the required state. Any impurities in the charge, whether derived from the materials of the furnace walls or from the gangues of the oxygenated metal, will, according to the inventor, on the sufficient continuance of the high temperature required, enter into the alumina slag. (See also our Vol. I., p. 523.)

**Calcium Carbide Furnace.**—E. Appleby, 803,147, Oct. 31. Application filed Jan. 28, 1905.

The inventor has devised an arc furnace for the production of calcium carbide. The main object is to provide a limited zone of intense heat into which powdered lime and coke are continuously fed, and from which the formed carbide is continuously withdrawn. The construction is



clearly indicated in claim 1: "In the electric furnace, the combination of a vertically-disposed tubular receptacle open at the bottom; a second receptacle surrounding the first, and having a bottom movable in alinement with said first receptacle; a pair of electrodes mounted in said frame and extending into the furnace near the lower end of said first receptacle; mechanism for gradually moving said bottom downwardly away from said electrodes, and mechanism for agitating the walls of said first receptacle."

#### ELECTROLYTIC PROCESSES.

**Electrolysis with Insoluble Anodes.**—A. G. Betts, 803,543. Nov. 7. Application filed Feb. 16, 1905.

The yield from anodic oxidations is increased, the life of the anodes is prolonged, and the necessary voltage is reduced by very greatly increasing the speed with which the layer of solution in contact with the anode surface is changed. The inventor uses anode rods and gives them a reciprocating motion in a direction perpendicular to their length. For instance, in electrolyzing a solution of ferrous and cupric sulphates, with a diaphragm, depositing copper on a cathode and oxidizing ferrous to ferric sulphate at the anode, and with a circulation of electrolyte that was previously considered amply sufficient, the e. m. f. required to work the cell was considerably reduced, the evolution of gas at the anode was entirely stopped, and the current efficiency raised from 50 to 100 per cent on giving the anodes a reciprocating motion of 100 complete cycles per minute, with an amplitude of about 1 inch. Other examples of the application of this method are the oxidation of organic substances and the manufacture of chromic acid from chromium sulphate.

**Treatment of Anode Slimes.**—E. F. Kern, 803,601, Nov. 7. Application filed March 27, 1905. (Assigned to A. G. Betts.)

The inventor treats lower-grade slime from the treatment by electrolysis of lead alloys containing a large quantity of antimony or arsenic, as follows: He oxidizes the slime by a gentle roast, driving off most of the arsenic as arsenious acid and converts the antimony into trioxide, so that it can be subsequently dissolved from the product with a suitable solvent, preferably hydrofluoric acid. Moistening the slime with dilute or concentrated sulphuric acid facilitates the roasting and prevents sintering of the slime. A temperature below a red heat is preferred, since if the temperature reaches a red heat the antimony goes into tetra and pent oxide, which is not easily soluble. The process is also applicable to the treatment of copper anode-slime containing much copper sulphide converted by roasting into copper oxide and sulphate. Before extracting the antimony from the product the inventor treats it with an acid solution of ferric sulphate or other oxidizing acid solution to complete the oxidation of antimony, arsenic, etc., and to remove any copper. After extracting the antimony the slime is ready for fire treatment. Silver may be extracted with the copper, if desired, or left to be recovered by fire processes, in whole or in part.

**Tank for Refining Lead.**—A. G. Betts, 803,544. Nov. 7. Application filed March 18, 1904.

For his lead refining process the inventor uses a tank with a wooden body, lined with copper plates upon its bottom and sides. These plates are joined together along their contiguous edges by solder. To the central portions of the copper plates thus soldered together is applied a coating of insulating paint which extends to within a short distance of the line of solder which lies along the joint of the lining, leaving a narrow strip of bare copper exposed along the opposite sides of the lines of solder. The tank is then filled with acid copper sulphate solution, and is connected in an electric circuit as a cathode. The sol-

dered surfaces thereby become covered with a coating of pure copper, so that there is a substantially integral copper lining over the soldered surface. Finally, the whole interior of the tank is covered with an insulating paint. But it appears that the insulating-paint cover is not strictly necessary, since "the copper lining of the tank, although capable of being dissolved by the electrolyte, is protected from attack by the same by reason of its potential relatively to that of the anode." Mr. Betts has demonstrated by experiment with such an apparatus, using an anode from which lead was dissolved by the electrolyte, that the copper lining of tank assumes a potential intermediate between the anodes and cathodes, and is not in the slightest degree attacked or dissolved by the electrolyte, and by the use of this apparatus he has electrodeposited lead which contains less than one part of copper to one million parts of lead.

**Electrolysis of Sodium Sulphate.**—H. S. Anderson, 803,263. Oct. 31. Application filed June 21, 1905.

The general problem of the electrolytic production of caustic soda and sulphuric acid from sodium sulphate was discussed on page 286 of our August issue. H. S. Anderson uses for this purpose a combination of a mercury cathode cell and a diaphragm cell. If simply a diaphragm cell would be used, the recombination of the anodically-formed sulphuric acid and of the cathodically-formed caustic soda could not be effectively prevented. For this reason a mercury cathode is used, the sodium ions when discharged forming an amalgam which is decomposed in a different compartment. It is also necessary, however, to prevent the anodically formed sulphuric acid from passing over to the mercury cathode. The inventor, therefore, provides a diaphragm above the mercury cathode, and below the anodic compartment and further passes a continuous stream of sodium sulphate solution between this

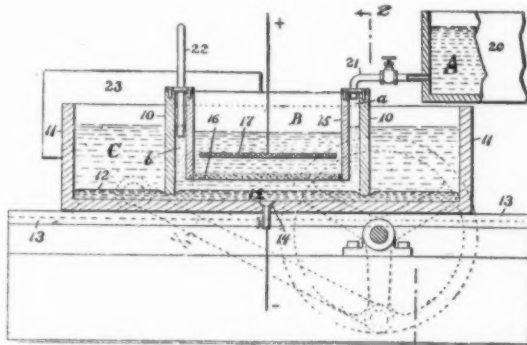


FIG. 1.—CELL FOR ELECTROLYSIS OF SODIUM SULPHATE.

diaphragm and the mercury cathode, so that any acid which might pass through the diaphragm is carried away with this stream of solution and cannot reach the cathode. A cross-section of the cell is shown in Fig. 1. A is a reservoir containing sodium sulphate, B is the electrolytic cell proper, and C the cell in which the amalgam is decomposed for the production of caustic soda. In B there is the anode 17, the diaphragm 16 and the mercury cathode 12. A continuous stream of sulphate solution is passed between 16 and 12; it flows from the supply tank A to the inflow-passage a, then passes between 16 and 12, and is taken off through the outlet-passage b by a syphon 22.

**Collection of Gases from Electrolysis.**—G. E. Cassel, 804,931, Nov. 21. Application filed May 4, 1905.

To prevent the gases developed either at the anode or at the cathode from passing over to the other electrode, he constructs each electrode as follows: Each electrode is

made of two conducting end plates, facing each other. The outside surfaces of these end plates are insulated so that no gas can develop on them. The two inside conducting surfaces are provided with a number of plates inclined upwards, above one another; the ends of these inclined plates face each other, but there is a free space between them. The top surfaces of these inclined plates are covered by plates of glass or otherwise insulated. All the gas formed develops on the under sides of the inclined plates, and in striving to ascend the gas is compelled to pass to the free space in the center, where it rises upwards into a closed hood provided with a pipe.

**Apparatus for Electrolysis of Chlorides of Alkalies.**—F. J. Briggs, 802,960, Oct. 24. Application filed Jan. 19, 1905.

Mechanical details of construction, the object of which is the improvement of details of his electrolytic cell, patented May 12, 1903 (patent 727,889, described in our Vol. I, p. 392). He reduces the weight of his cell by doing away with his former cathodes by balancing the "dialyzers" by means of a system of levers and comparatively small weights, the tank being made of iron and the perforated iron sheets which make parts of the dialyzers operating together with the iron tank as cathode. There are also some other modifications of his former cell construction.

**Manufacture of Seamless Hollow Articles.**—F. A. Voelke, 789,342, May 9. Application filed Jan. 20, 1904.

Mechanical details of a method for making seamless hollow articles, such as floats, cylinders for holding compressed air, etc. In a proper mould a core or pattern of the desired form is first made from paraffin or wax, etc.; for this purpose the mould is heated and revolved, after molten paraffin, etc., has been poured into it; compressed air is simultaneously introduced to force the paraffin against the face of the mould. After the paraffin core has thus been formed it receives a graphite coating and then an electrolytic deposit. It is now suspended with the passage, through which air was introduced before, downwards, and is then heated above the melting point to paraffin. The paraffin core is thus melted within the metallic shell, and is in part reduced to vapor, which forces the paraffin out through the former air hole. The shell is finally thickened by alternating dipping into a fused bath and electrolytically depositing other layers.

#### ELECTRIC DISCHARGES THROUGH GASES.

**Nitrogen Oxides by Electric Discharges.**—E. Marquardt and H. Viertel, 804,021, Nov. 7, 1905. Application filed May 2, 1903.

A mixture of oxygen and nitrogen gases performs a cycle, continuously passing through an electric arc discharge, and thence to a cooling or absorbing apparatus, then returning to the arc, etc. "Thus a definite quantity of gas is gradually enriched with oxides of nitrogen until a concentration is reached, at which every excess of product is retained in the cooling or absorbing apparatus." The principle is shown in Fig. 2, where *b* is a system of pipes forming a closed cycle; *c* represents the electrodes when the arc discharge takes place; *d* is a vessel containing a cooling substance, like solid carbonic acid; *e* a condenser in which the formed product collects, and from which it may be drawn off by means of the spigot *f*. *A* is a vessel containing the raw material. A sufficient automatic circulation can be maintained by the difference of temperature between the arc and the condenser, if the former is so arranged so as to allow the warmed gas mixture to rise up, and if the cooling part of the circuit be directed downward. For this purpose the arc is placed at

a low position in the rising branch of the circuit. Continuous working is possible, which requires only very little supervision. If several arcs are employed they are arranged side by side, in order to prevent the gaseous mixture from passing through several arcs in series, whereby a partial reduction of the formed oxides would be caused. For producing as cheaply as possible nitrates or compounds containing oxides of nitrogen, they use 30 to 100 volts and cheap mixtures of nitrogen and oxygen, such as atmospheric air, under a pressure of 1 to 2 atmospheres. For producing pure nitrogen tetroxide the best results are obtained by using a constant mixture of 50 per cent oxygen and 50 per cent nitrogen, and replacing the oxygen and nitrogen which have combined by adding continuously a mixture containing two volumes of oxygen to one of nitrogen; pressure 5 atmospheres, voltage 5,000 to 10,000. For the arc discharges the inventors use electrodes which contain compounds of metals, especially fluorides, chlorides, borates, silicates, or oxides of the alkalies or earthy alkalies or of magnesium or mixtures of these. A specially effective electrode consists mainly of carbon, and contains from 10 to 30 per cent of fluorspar. One effect of these additions is a reduction of the resistance of the arc and the production of a very large and voluminous arc.

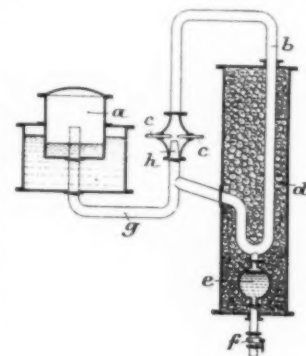
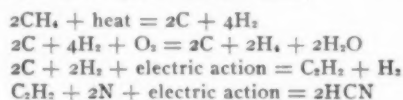


FIG. 2.—PRODUCTION OF NITROGEN OXIDES.

**Production of Cyanide of Ammonia, Hydrocyanic Acid, etc.**—A. M. Gow (assigned to George Westinghouse), 801,728, Oct. 10. Application filed Dec. 9, 1902.

Natural gas, the composition of which is about 95 per cent methane,  $\text{CH}_4$ , is mixed with nitrogen or air and the mixture passed through an electric arc discharge to produce hydrocyanic acid. The temperature must be high enough to result in the fixation of the nitrogen, but not high enough to decompose again a great part of the compounds formed. The arc should be "sputtering violently when the reaction goes on. When the arc remained quiet and steady between the electrodes, the desired production of nitrogen compound was not obtained, but carbonic acid was formed." The inventor has found "that a mixture of half natural gas and half air, upon being passed once through the heating chamber, would give a recovery, based on the carbon contents of the cyanides formed, equivalent to 5 per cent of the carbon originally contained in the mixture. Again, from 1 liter of natural gas and 1 liter of air I have recovered 0.065 grams  $\text{C}_2\text{N}_2$ , which would be equivalent to 0.164 grams KCN. In another experiment from the same mixture I have recovered 0.0578 grams  $\text{C}_2\text{N}_2$ , equal to 0.145 grams KCN." The following reactions are stated to occur simultaneously:



Furthermore, the nitrogen enters into combination with hydrogen in other forms than as hydrocyanic acid, HCN; the inventor has obtained ammonia, "which in all probability, in the presence of cyanogen, would exist as ammonium cyanide."

## SYNOPSIS OF PERIODICAL LITERATURE.

## A Summary of Articles Appearing in American and Foreign Periodicals.

## INDUSTRIAL ELECTROCHEMISTRY.

**Fixation of Atmospheric Nitrogen by Electric Discharges.**—A long series of experiments on the production of oxides of nitrogen by means of electric discharges through air has been made by Otto Scheuer. The results are printed in form of a thesis in French language (for the degree of Doctor of Physical Science, University of Geneva, 1905), and a German translation in abstract may be found in the "Zeit. f. Elektrochemie," Sept. 1. The experiments were made partly with a Ruhmkorff induction coil and partly with a high-tension transformer. The author determined the output as a function of the velocity of the stream of air, the distance between the electrodes, the watt consumption, the material of the electrodes and the form of the apparatus, using both dry and moist air.

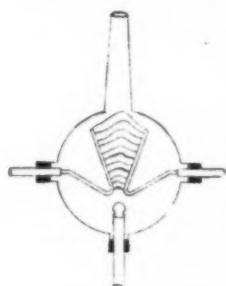


FIG. 1.—ARC DISCHARGE.

The results are given in tables and diagrams. Some of his devices are quite interesting. With the induction coil good results were obtained when the arc was formed between the two horns of a horn lightning arrester, as shown in Fig. 1. He thereby obtained a series of arcs traveling upwards between the two horns. Another form is shown in Fig. 2. The air is introduced through the hollow pipe on the left hand, which serves as one electrode. The other electrode (right hand) is provided with a cone through the central opening of which the nitrous vapors are sucked off. The two electrodes were stationary, although it would have been better to revolve either the funnel electrode centrally or the pipe electrode excentrically, since in this case a true cone of flames would have been obtained, while with the stationary electrodes only several flame bands from the end of the pipe to points of the periphery of the cone were obtained. The flame bands choose the smallest roughness on the periphery, and, by previous filing, the flame bands may be directed to special points. The output with this form of apparatus was relatively high. The results obtained in three experiments of this kind are as follows:

TEST NO.	1.	2.	3.
Primary watts.....	162.5	162.5	162.5
Duration of experiment in minutes.....	110.	110.	110.
Quantity of air in cc.....	10,800.	10,800.	28,800.
cc of air per minute.....	98.18	163.64	261.81
Watt-hours consumed.....	297.9	297.9	297.9
Total NO obtained in cc.....	1.8753	2.2461	2.8305
Grams of NO producing HNO <sub>3</sub> .....	0.9048	1.1013	1.4003
Grams of NO producing HNO <sub>3</sub> .....	0.9705	1.1448	1.4302
Percent of NO producing HNO <sub>3</sub> .....	48.25	49.03	49.47
Percent of NO producing HNO <sub>3</sub> .....	51.75	50.97	50.53
Percent of volume of air producing NO <sub>2</sub> .....	19.42	13.95	10.97
Percent of volume of oxygen producing NO <sub>2</sub> .....	61.48	44.23	34.85
Grams NO <sub>2</sub> produced by 1 kw hour.....	9.6480	11.5560	14.5630
Grams HNO <sub>3</sub> produced by 1 kw hour.....	6.3752	7.7590	9.8658
Grams HNO <sub>3</sub> produced by 1 kw hour.....	5.1026	6.0190	7.5195

The general results of the author are as follows: In spite of the great number of experiments made with the most varied apparatus the efficiency was poor compared with the theoretical one, on account of the losses in the induction coil and in the transformer employed. The frequency used in the transformer experiments was too low. The experiments show, however, very decidedly how much the efficiency depends upon proper design of the whole apparatus and of the electrodes and upon a proper

method of the air supply and removal. Spark discharges are not suitable for the formation of nitrogen oxides; it is necessary to use the flame of the voltaic arc. This flame should be extended over a large active region. In order to increase the effect several arcs should be employed. The duration of the action of an arc upon a quantity of air should be reduced to a minimum, and the nitrogen oxides

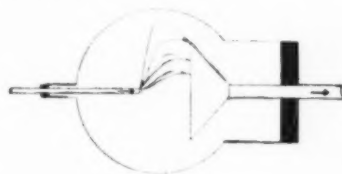


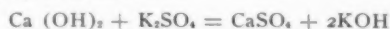
FIG. 2.—ARC DISCHARGE.

formed should be removed immediately from the active region of the arc. The form and dimensions of the apparatus in which the discharges take place as well as the construction of the pipes through which the air is supplied

and removed are of very great importance. Moist air gives better results than dried air. For certain values of the e. m. f. current and frequency the combination of nitrogen with oxygen becomes a maximum.

**Electrolysis of Alkali Chlorides.**—A somewhat peculiar method of winning caustic alkalis and chlorine by electrolysis of aqueous solutions of alkali chlorides is described in the "Zeit. f. Elektrochemie" of Sept. 15, from German patent 160,967, Kl 12 I; granted June 13, 1905. Carbon plates are placed opposite to plates of solid silver-plated lead, which have numerous perforations filled with porous silver. There is no diaphragm. Alkali chloride solutions of 20° to 22° Be are electrolyzed at about 2.5 volts. The silver anode becomes covered with a layer of silver chloride, while at the carbon cathode NaOH is formed with evolution of hydrogen; 95 per cent of the NaCl are stated to be transformed into NaOH, while the Cl is bound in the silver plates. The solution is then removed, the cell is refilled and the electric current is passed through it in the opposite direction, so that AgCl is reduced and chlorine is set free at the carbon anode. Chlorine and hydrogen are, therefore, set free in different steps of the process, and chlorine does not come into contact with NaOH. "The AgCl cannot pass from the anode into the solution (although it is soluble in NaCl solution), because the Ag would at once be redeposited again by the current." The inventor is J. Heibling.

**Caustification of Potassium Sulphate.**—In the "Zeit. f. Elektrochemie" of July 7, Ignaz Herold investigates the equilibrium between potassium sulphate and calcium hydroxide, and discusses at the same time the commercial possibilities of producing caustic potash or soda by directly treating a sulphate solution with caustic lime, as indicated by the reaction



He thinks a commercial application of this reaction is not impossible. Former investigators who worked in this line made the mistake to use a high temperature, while the author finds that at low temperatures (0° C.) the output becomes comparatively high.

**Pure Magnesia.**—Extended experiments made in the laboratory of the Royal Porcelain Factories, in Berlin, have resulted in the successful manufacture of various commercial articles from pure magnesia. According to a note in the "Zeit. f. Elektrochemie" of Sept. 1, tubes up



to 80 cms. length and 7 cms. diameter, with a wall thickness of 7.5 cms., can be made, also crucibles up to 50 cms. height of any diameter and any thickness of walls. When suddenly heated in the air-blast flame the articles do not crack nor do they change their form. Tubes made from this pure magnesia and heated in the electric furnace to  $1,750^{\circ}\text{C}$ ., did not show any shrinkage nor—"and this is the most essential point—any trace of electrolysis."

#### ELECTROPLATING.

**"Kupron System."**—At the recent electrical exposition at Olympia, London, a large assortment of various articles was shown, mostly used in the electrical industries, and ranging from small switch fronts and light fittings to an entire shop front. The idea is to make the articles of clay and then electroplate them. There is nothing essentially new in the "Kupron" system, as it is called. First, the light fitting—or whatever the article may be—is modelled in clay, and the clay is then covered with a thin film of black lead. By immersing the latter as cathode in a copper bath, a layer of copper of any desired thickness is electrolytically deposited on the mould. The finish is bronze, silver, gold, etc. According to the London "Electrician" of Oct. 27, the chief advantage of the process is the low cost of the finished article, "electric light fittings and other things of a similar kind costing not more half what they would have cost if produced in the ordinary way."

#### THEORETICAL AND EXPERIMENTAL.

**Magnesium Anodes.**—In "Zeit. f. Elektrochemie," July 28, G. Baborovsky describes some peculiar properties of magnesium anodes. In neutral solutions of chlorides, sulphates, etc., hydrogen is developed at the magnesium anode, and a black powder goes into solution, the so-called "Beetz suboxide," which, however, is probably only powdered metallic magnesium. The potential at which this takes place is approximately the same as shown by metallic magnesium when no current flows. In alkaline solutions at least three conditions of the surface of a magnesium anode must be distinguished, namely, the original condition, the passive state and the pseudo-active state. As a result of the peculiar behavior of magnesium anodes the following interesting oxidations and reductions may be produced at the same: In neutral solutions,  $\text{KMnO}_4$ ,  $\text{K}_2\text{CrO}_4$  are reduced,  $\text{I}^-$  ions are oxidized to  $\text{I}_2$ . In alkaline solutions  $\text{Br}^-$  ions and  $\text{I}^-$  ions are oxidized to  $\text{BrO}_2$  and  $\text{IO}_2$  ions respectively,  $\text{KMnO}_4$  is reduced to  $\text{K}_2\text{MnO}_4$ ,  $\text{Cl}^-$  ions are not changed. The author considers the passive state in alkaline solutions as due to a non-conducting film which contains scratches through which conduction takes place.

**Copper and Zinc in Potassium Cyanide Solutions.**—A long paper on this subject is published by Fritz Spitzer in the "Zeit. f. Elektrochemie," June 9 and 23. The first part deals with potential measurements, the second with electroanalysis. The potentials of copper and zinc towards their potassium cyanide solutions depend upon the concentration of the salt solutions and their content of  $\text{KCy}$ . They are higher for higher concentration of the salt solution, and are increased by increasing the  $\text{KCy}$  content. These influences manifest themselves more strongly with copper than with zinc. When mixed copper- and zinc-potassium-cyanide solutions are electrolyzed, zinc is deposited together with copper long before the proper potential of pure zinc is reached. This proves electrolytic brass to be a true alloy and not a mixture. In his electroanalytic experiments the following results were obtained: When zinc or copper are deposited from potassium cyanide solutions, the platinum anodes are attacked and the platinum which dissolves at the anode is deposited on the cathode. Hence the determination of copper or zinc cannot be exact. The complete deposition of copper and zinc takes a very

long time, since the last traces are deposited only from solutions free from cyanide, and the removal of the cyanide from the solution by anodic oxidation requires considerable time. The anodic oxidation is quickest with a low alkalinity of the solution (about 0.2 normal). In general the addition of potassium cyanide is a superfluous complication of the quantitative electroanalytic deposition of copper or zinc.

**Alternating-Current Electrolysis.**—Some further experiments are described by A. Brochet and J. Petit in "Zeit. f. Elektrochemie" of July 14. The general result confirms the view that the total result is the sum of the anodic and cathodic actions which follow each other continually at each electrode. The ions discharged during one-half wave must be removed in some way from the sphere of action in order to prevent their passing again into the ionic state. Reaction velocities have a considerable influence, so has the frequency and the current density. An increase of current density facilitates the discharge of free ions and increases their number per unit of surface. During the reactions the electrodes sometimes change their nature and become spongy. The most interesting results are the solution of Pt and Pb in  $\text{H}_2\text{SO}_4$  and of Pt and Fe in cyanide, and the change of electrode surfaces into a spongy condition.

**Iron Titration Coulometer.**—In "Zeit. f. Elektrochemie," Aug. 4, Z. Karaoglanoff describes an iron titration coulometer (voltameter) which is suitable for exact measurements, especially of small currents. The principle is the cathodic reduction of a ferric salt solution to ferrous salt, together with titration with  $\text{KMnO}_4$ . The construction of a coulometer is described by which a quantity of electricity passing through it may be determined with a mean error of 0.23 coulomb.

**Colloidal Solution of Tellurium.**—In the "Zeit. f. Elektrochemie," Aug. 18, E. Mueller and R. Lucas describe the formation of a colloidal solution of tellurium by cathodic disintegration. The loss of weight of the cathode is proportional to the coulombs passed, the tellurium behaving as a monovalent element.

**Temperature and Speed of Development of Animal Life.**—In "Zeit. f. Elektrochemie," Aug. 18, R. Abegg points out some interesting analogies between the influence of temperature on the speed of development of the animal life from eggs and the influence of temperature on the speed of chemical reactions. For the temperature coefficient of the latter Van't Hoff has given a general rule and Abegg shows now that this rule also applies to those cases of animal life investigated, namely, the eggs of echinus microtuberculatus, and of sphaerechinus granulatus, as well as Hertwig's researches on rana. In "Zeit. f. Elektrochemie," Oct. 20, A. Kanitz gives analogous considerations with respect to the influence of temperature on carbon dioxide assimilation by plants.

**Electrolytic Production of Nitrites from Nitrates.**—In "Zeit. f. Elektrochemie," Aug. 11, E. Mueller and F. Spitzer give results on the electrolytic reduction of nitrates to nitrites on cathodes of different materials. Spongy silver was found to be the best cathode material, spongy copper the next best material; gold is unsuitable.

**Stearic Acid.**—Some experiments on the electrolytic reduction of oleic acid to stearic acid are described by J. Petersen in "Zeit. f. Elektrochemie," Aug. 25.

**Rotating Cathode.**—C. P. Flora has formerly studied the use of the rotating cathode for the estimation of cadmium taken as a sulphate. In the November issue of the "American Journal of Science" he describes a series of experiments on the estimation of cadmium taken as the chloride with the aid of the rotating cathode.

**Tantalum and Hydrogen.**—Tantalum metal, incandescing in the atmosphere of a gas, is considerably modified in its properties. M. von Pirani gives in "Zeit. f. Elektrochemie," Aug. 25, an account of the changes of tantalum when incandescing in a hydrogen atmosphere. There is both a chemical combination of tantalum and hydrogen and an occlusion of hydrogen. The properties of tantalum are modified by the chemical combination only.

**Solution Tension.**—In "Zeit. f. Elektrochemie," Aug. 4. C. Fredenhagen endeavors to give the foundations of a general theory of the electrolytic solution tension of different materials in different solvents.

**Semipermeable Membranes of Clay.**—P. Rohland remarks in "Zeit. f. Elektrochemie," July 14, that not all clays can be used for semipermeable membranes. Highly plastic clays in air-dried condition are most suitable.

#### IRON AND STEEL.

**Bessemer Open-Hearth Practice.**—C. Canaris describes in "Stahl und Eisen" for Oct. 1, the combined Bessemer and open-hearth steel practice now being followed at Witkowitz, in Austria. The larger part of the silicon, manganese and carbon is removed by blowing in an acid-lined converter, giving hot metal for further treatment in the basic-lined open-hearth furnace. Three converter charges, of 7 to 10 tons each, are run off in succession in 6 to 12 minutes each, and poured successively into the Siemens furnace. In the latter there is placed about 1 ton of burnt lime,  $\frac{1}{2}$  ton of iron ore,  $\frac{1}{2}$  ton of pig iron, a ton of steel turnings, and afterwards added 1.5 ton of 77 per cent ferromanganese. The output of steel is about 90 per cent of the weight of pig iron and scrap used. The open-hearth treatment lasts 3 hours. With two Bessemer converters of 10 tons capacity, and three 25-ton Siemens furnaces running, the plant turns out 450 to 500 tons of steel ingots daily. Test analyses showed:

	Pig Iron.	Blown Metal.	Finished Metal.
Si .....	1.40	0.044	traces
Mn .....	3.30	0.310	0.300
C .....	3.08	0.143	0.100
P .....	0.303	0.318	0.013
S .....	0.025	0.029	0.021

The advantages of this method of working are undoubtedly a large output, because of the quick heating up of the steel, but at the sacrifice of smaller percentage output than regular open-hearth work. Under the conditions prevailing at Witkowitz it has paid, for many years, to run in this manner, and thus it forms a very interesting example of successful practice, under unusual circumstances, of a combination usually regarded as impracticable.

**Equilibrium in the Blast Furnace.**—R. Schenck and F. Zimmermann have carried out at the University of Marburg some extensive tests on the chemical equilibrium between iron, ferrous oxide, carbon, carbon monoxide and carbon dioxide. Their results, as given in "Stahl und Eisen" for Oct. 1, are that carbon monoxide deposits carbon by the reaction  $2\text{CO} = \text{C} + \text{CO}_2$  only in presence of free iron (or free metals of the iron group), and is not caused by the oxides of these metals. Carbon monoxide does not oxidize metallic iron directly, but indirectly, in that the iron causes deposition of carbon and formation of  $\text{CO}_2$ , which latter then oxidizes iron to  $\text{FeO}$ , regenerating  $\text{CO}$ . This reaction proceeds until complete equilibrium between all five substances is attained, which can only occur, according to the phase rule, for a single partial pressure of each of the two gases and at a single total pressure on both gases. If the partial pressures of  $\text{CO}$  and  $\text{CO}_2$  in the furnace, taken together, are greater than this single critical pressure, then oxidation of the iron can take

place, with deposition of carbon; if the pressure is less, carbon can be deposited but no iron oxidized.

The value of this critical equilibrium pressure varies only with the temperature, and was determined as follows:

At 500° C. =	15 mm.
550° C. =	35 "
600° C. =	70 "
650° C. =	145 "
700° C. =	305 "
750° C. =	535 "
800° C. =	800 "

Since the partial pressures of  $\text{CO}$  and  $\text{CO}_2$  are seldom less than 250 mm., reduction can take place down to 690° C., and below that it stops. A curious conclusion from this would be that the smaller the percentage of  $\text{CO}$  and  $\text{CO}_2$  in the furnace gases the lower the temperature at which reduction would continue to take place; and that the more nearly the furnace was run by pure oxygen, the higher the temperature would be at which reduction would stop. This is a new point of view, which may have a practical bearing on blast furnace running under some circumstances.

**Blast Furnace Design.**—J. L. Stevenson, in "The Engineer" for Aug. 25, discusses the manner in which a blast furnace of given capacity can be designed. His methods may be practical and all right, but they are curious. First of all, if it is intended to make, say, 260 tons of iron in 24 hours, the designer commences by the statement that a furnace to make this amount should be 80 feet high and 18 feet in maximum diameter at the bosh. The diameter of crucible is taken as 0.63 of the bosh, and that of the throat 0.67 of the bosh. The make of iron being about 11 tons an hour, the slag notch is made 4 feet 3 inches above the floor of the crucible, so as to leave ample space for the iron, and the tuyeres are placed 2 feet above the slag notch. The blast required is assumed as 140 cubic feet per minute per ton of iron made in 24 hours; and the tuyere area required as  $1\frac{1}{4}$  square inches for each 140 cubic feet of blast per minute. Ten  $6\frac{1}{2}$ -inch tuyeres will suffice for the furnace, furnishing the 36,400 cubic feet required per minute (the pressure required is not stated or calculated). The hot-blast stoves should have a heating surface altogether of 444 square feet for each 140 cubic feet of blast heated per minute, or altogether 115,440 square feet.

Some approximate formulæ (of only very limited application, however), are:

- (1) The output, in tons per day, equals the cube of 0.35 times the diameter at the boshes, expressed in feet.
- (2) The output, in tons per day, equals the cube of 0.08 times the height, expressed in feet.
- (3) The output, in tons per day, equals the square of the diameter at the boshes, times the height (all in feet), divided by 100.

These formulæ can be used only in comparing furnaces of nearly similar dimensions, and even then they will be often far from the truth.

**Avoiding Shrinkage Cavities.**—F. O. Beikirch describes in "Stahl und Eisen," Aug. 1, a method of avoiding shrinkage cavities in heavy steel ingots which has been put in successful use during this year at the Gutehoffnungshütte at Oberhausen. The idea is to keep the steel in the upper part of the ingot fluid by the use of a producer gas blow-pipe, so that all shrinkage cavities can be filled. The apparatus consists of a small gas producer on a track, supplied by air blast from a knee-jointed air pipe. Part of the air passes through the coke fire, making producer gas, to which the rest of the air is supplied in the pipe leading into the top of the ingot mould. The warm air burning the hot gas completely produces a very hot flame. The gas is thus burned in the empty mould for some minutes

previous to casting; then the pipe removed while the ingot is cast, and then the cap replaced and the heating continued. The cost of the treatment is given as 15 to 25 cents per ton of steel; the cost of the apparatus \$1,250 to \$1,500. The amount of top which must be cut off the ingot is thus reduced from 10 to 15 per cent of the weight of ingot to an average of 5 per cent; and 5 per cent good metal thus obtained instead of 5 per cent of scrap is well worth the steel-master's attention.

**Grondal Process.**—The International Exposition at Liège is reviewed in a series of articles in "Stahl und Eisen," commencing June 1. The number of Aug. 1 contains an extensive table, taken from the exhibit of the Stockholm firm, "Metallurgiska Patent Aktiebolaget," of the results of magnetic concentration of iron ores by the Grondal process. The fine ore is concentrated, briquetted and roasted. American ore, containing 50.65 iron, 1.603 sulphur, and 0.012 phosphorus, was concentrated to 69.95 iron, 0.036 sulphur and 0.003 phosphorus, the residues carrying only 19.20 of iron. Swedish ore carrying 1.29 per cent phosphorus was concentrated to 0.011 phosphorus. Altogether some sixty-two specimens were shown, with analyses, and formed a very striking and instructive exhibit of the capacities of this system.

**Ferrotitanium.**—The September issue of "Cassier's Magazine" contains a useful and interesting article by A. J. Rossi on ferrotitanium. The author first describes the manufacture of ferrotitanium, either by the Goldschmidt process or by his own electric furnace process (our Vol. I., p. 523), and then gives a summary of the various applications of ferrotitanium in the steel industry.

#### LEAD.

**Huntington-Heberlein Process.**—In our October issue (p. 363) we discussed the principal features of the Huntington-Heberlein process of roasting galena, which is now in the foreground of interest owing to its adoption at several smelters of the American Smelting & Refining Co. In this connection several articles recently published are very interesting. In the "Zeit. f. d. Berg-Huetten u. Salinen-Wesen," No. 2, A. Biernbaum gives comparative results obtained in an Upper-Silesian smelter up to 1900 with hand-roasting furnaces, and since that time with the Huntington-Heberlein process. The advantages of the latter process are indicated in figures showing the reduction of workmen required, a very essential reduction in the cost of maintenance of the furnaces, a large reduction in the coal consumption and improved sanitary conditions. Since the roasting temperature is smaller, there is less volatilization of lead and less flue dust. Whatever the percentage of zinc in the ore is always roasted in the same furnaces (whereas formerly different ores were roasted in different furnaces). The total charge of the blast furnace is now richer in lead than formerly, and a larger output can now be obtained. The reduction in the number of workmen is largely due to the introduction of mechanical machinery, but the cost of power for this purpose is stated to be small. As disadvantages of the process are mentioned the difficulty of breaking up the roasted cake from the converter and the higher content of sulphurous acid in the waste gases; it is hoped, however, that it may become possible to utilize the latter for the manufacture of sulphuric acid.

The theory of the Huntington-Heberlein process is the subject of various articles. In "Metallurgie" of Sept. 22, C. Guillemin gives a very full discussion of the probable reactions. He does not agree at all with the hypothetical reactions of the inventors, who assumed the formation of calcium peroxide as the principal reagent. In his opinion

the addition of lime has no essential chemical effect, but influences the physical condition of the material in such a way that it may serve as a heat reservoir to prevent the localization of heat with a resulting melting of galena, instead of roasting.

In connection with this subject, a paper by F. O. Doeltz, in "Metallurgie" of Oct. 8, is also interesting. It refers to a claim of A. D. Carmichael to the effect that a mixture of lead sulphide and calcium sulphate, when heated to 400° C., reacts according to the equation:



Doeltz describes a series of experiments which show that this reaction does not take place. On the contrary, when lead sulphate and calcium sulphide come together there is a tendency to form lead sulphide and calcium sulphate. Nevertheless, when a mixture of lead sulphide and gypsum is heated in air, lead sulphate will be formed besides lead oxide, but not as the result of a reaction between lead sulphide and calcium sulphate, but as a result of a reaction of lead oxide and contact sulphuric acid:



This is the reaction which regularly takes place when lead sulphide is roasted, and the explanation of which was already understood by Plattner.

**Direct Desulphurization of Galena by the Air Blast.**—It is well-known that the Huntington-Heberlein process has already found competitors. One of them, A. Savelsberg, describes his process as operated at Ramsbeck, in Westphalia, in the November issue of the "Mining Magazine." The principal distinguishing feature is the desulphurization of raw galena directly in the converter without any preliminary roasting. He introduces into the converter a mixture of raw lead ore and limestone, containing a sufficient amount of silica for the formation of silicates. A current of air is then blown through it, while at the same time that portion of the mixture which is adjacent to the opening where the air enters is ignited. Very active reactions are produced by the combustion of the sulphur of the ore. There are produced lead oxide, sulphurous acid, carbonic acid, sulphuric acid, sulphates and silicates. Sulphurous acid and carbonic acid escape, and a part of the sulphates acts directly, oxidizing on undecomposed galena. Another part of them is decomposed by the silica. During this process sulphuric acid is set free, which acts as a powerful oxidizing agent. The lead oxide thus formed combines finally with the gangue of the ore and the non-volatile components of the additions to the desired roasted product. Several precautions must be taken during operation. A good mixture of the charge must be carefully looked after. The converter is not filled completely at once, but the charge is added gradually in thin layers. In order to prevent an unmixing of the mixture of ore and limestone, by reason of the blowing away of the light particles of limestones, it is requisite to add a comparatively large amount of water to the charge before it is introduced into the converter.

#### RECENT METALLURGICAL PATENTS.

**Refining Copper-Nickel Matte.**—In separating the sulphides of nickel and copper by the Orford process, as operated at the Bayonne works of the Orford Copper Company, the practice is to subject the molten matte to contact with sodium sulphide (produced generally by mixing sodium sulphate and coke with the matte), smelting in a cupola furnace and causing the copper and iron sulphides, which are dissolved in the resulting sodium sulphide, to



separate under the influence of gravity from the heavier undissolved nickel sulphide. A recent patent of R. R. Maffett (802,148, Oct. 17) refers to a new simplified treatment of the resulting copper-iron tops. These tops are piled in the open, where the action of the weather oxidizes the sodium sulphide to sodium sulphate. They are allowed to weather about eight weeks, whereby the greater part of the sodium sulphide is oxidized to sulphate. As soon as the tops, thus treated, are smelted, the sodium sulphate rises to the top of the charge and is drawn off into pots, when it is allowed to cool and is returned to the nickel cupolas, where it is used in place of refined salt cake. The conversion of the sodium sulphide to sodium sulphate is completed by oxidation preferably by an air-blast, and the oxidation is continued until all or nearly all of the sodium sulphide is converted into sulphate. The molten contents stratify in the furnace, and the different layers are tapped separately into different molds. By skimming or tapping off the floating layer of sodium sulphate or the layers of sodium sulphate and iron silicate and leaving the copper sulphide remaining in the furnace, the inventor is enabled to proceed in the same furnace with further refining of the copper.

**Detinning.**—The industry of detinning tinned sheet iron for the separation of tin and iron has so far only utilized tin scrap, bought of the manufacturers of tinned-iron cans, etc., as commonly used for preserves and canned goods. The cans and boxes themselves have scarcely been utilized up to the present, for several obvious reasons. One is that in their original form they cannot be used for the electrolytic process. To make them available for this purpose, they must be compressed so as to occupy a small room only, and must also be dressed so that the dissolving agent can circulate at both sides of the plates from which the tin is to be taken off. To accomplish this, a recent patent of Hans Goldschmidt (804,530, Nov. 14) describes means for compressing the cans and boxes between mechanically-moved surfaces and for perforating the boxes to allow the electrolyte easy access to all metallic parts.

**Roasting Furnaces.**—In the McDougall type of roasting furnace the dropping of the charge from one hearth to the next one and the raking off of the ore after discharge produces dust, which agglomerates as "secretions," or "bearings" on the roof of the upper hearth, and must be removed from time to time. This is very inconvenient, since it necessitates shutting down the furnace periodically. To overcome this disadvantage, F. E. Marcy (802,207, Oct. 17) provides the rabble arms with an extended plate or surface adapted to come directly over the discharge openings, so that the dust is deflected and intercepted before it reaches the upper hearth. Whatever accretions form on the extended surface mentioned before, can be removed or borne off from time to time through the furnace doors without closing down the furnace.

A. R. Meyer (804,751 and 804,752, Nov. 14) patents mechanical details of construction of the hollow central shaft and the hollow stirring arms so as to properly pass a cooling fluid through them. As cooling fluid he uses air saturated with water vapor.

The well-known Herreshoff roasting furnace has proven very successful in treating dry ore or other material, such as American pyrites, which can be stirred up during the roasting process without sticking or conglomerating in large masses. In the treatment of material containing considerable moisture, such as washed Spanish fines, there is danger that, if not previously dried, this material blocks the feed and cakes and balls up in such large masses that the stirrers cannot break it up, and the stirrers themselves are often broken. For this reason H. Howard (804,227, Nov. 14) provides a drying chamber on top of the furnace where the material is stirred and dried by means of the

waste heat of the furnace, before it is fed into the roasting furnace proper.

A. W. Chase (804,379, Nov. 14) patents a roasting furnace of the following construction: It consists of a series of troughs located one over the other and being U-shaped in cross-section and composed of fire-clay sections. The charge feeds from one trough to the next one. In the troughs conveyors are provided with hollow shafts. They are driven at increasing rates of speed from the top downward, while a cooling fluid is passed through the hollow shafts.

**Gold and Silver.**—T. B. Joseph (805,017, Nov. 21) patents the following modification of the cyanide process. The crushed ore is subjected to the action of a leaching solution containing water, sodium cyanide, calcium hydrate, ammonium carbonate, ammonium nitrate and sodium bicarbonate, while simultaneously compressed air is forced upward from the bottom of the tank from an air-compressor. If there was no carbon dioxide with the ammonia in the leaching solution, then the ammonia therein might decompose some of the cyanogen into its component parts and ruin its power to dissolve gold; but the carbon dioxide from the ammonium carbonate protects the cyanogen from such destruction. The cyanogen in the solution dissolves the gold, while the ammonium causes a better extraction of the silver, as well as of the copper or gold, with this solution than the straight cyanide process would yield. The inventor gives the following recipe: 1 ton of water,  $\frac{1}{2}$  to 5 pounds sodium cyanide, 1 to 50 pounds ammonium carbonate,  $\frac{1}{2}$  pound ammonium nitrate, and about enough of calcium hydrate to contain 1 pound of oxide of lime, and 2 pounds sodium bicarbonate.

E. Parrish (805,229, Nov. 21) patents a slimes filter of the following construction: The lower part of the horizontal filter tank is divided into several compartments. A filter body is placed over the same, and above it is the slimes chamber, which is common to all the compartments. The tank is rotated and a vacuum is produced in these compartments. It is thereby possible to separate a large percentage of the solution from the slimes at a single operation.

## BOOK REVIEWS.

**EXPERIMENTAL ELECTROCHEMISTRY.** By N. Monroe Hopkins. 284 pages and 130 illustrations. New York City: D. Van Nostrand Co. Price \$3.00.

This work of Dr. Hopkins, the well-known professor of George Washington University, is an elementary textbook for students in electrochemistry. In the words of the author it has been his aim "to produce a book that will prove useful in both the lecture room and laboratory." It is written in an easily understood and interesting style, and the directions for performing the numerous experiments, which cover a large range, are practically full. The book is well printed and the numerous illustrations will add greatly to its usefulness.

The first six chapters, occupying 116 pages, are devoted to fundamental principles in which the theory of electrolytic dissociation, electrolytic induction and conduction, Faraday's law and energy requirements are discussed and illustrated by experiments.

In the following chapters directions are given for making many compounds, both organic and inorganic, electrolytically as well as for the isolation of the metals sodium, potassium, aluminium and calcium, and a valuable feature of the book is the short historical sketch of the work that has been done in connection with their preparation.

ELEMENTS DE CHIMIE INORGANIQUE. Par Prof. W. Ostwald. Traduit de l'Allemand par L. Lazard. Two volumes. Paris: Gauthier-Villars. Price 28 francs.

Prof. Ostwald's writings are ever marked by clearness of conception and facility of diction in the original German. His "Elements of Inorganic Chemistry" is an epoch-making treatise. This has been rendered into French by Prof. L. Lazard, and the lucidness of style and thought is, in our opinion, almost enhanced in its gallicized form. For English-speaking chemists who read French more easily than German, these two volumes are to be recommended, for they are the product of a brain that looks on chemistry in a broad, philosophical light.

THE COPPER HANDBOOK. A manual of the copper industry of the world. Vol. V. for the year 1904. By Horace J. Stevens. Houghton, Mich.: Horace J. Stevens. 882 pages. Price \$5.00.

Mr. Stevens' annual Copper Handbook is now in its fifth year, and a comparison with former volumes shows that the author has taken great care and much pains in making the book thoroughly up to date.

The Handbook comprises sixteen chapters. The first six are of an introductory general character, and deal with the history of copper, geology of copper, chemistry and mineralogy of copper, the uses of copper and a glossary of mining terms. Then follow eight chapters on copper deposits in different countries.

The main value of the book is to be found in the last two chapters, on copper mines of the world and copper statistics. These two chapters have been entirely rewritten for the new edition, and contain an enormous amount of useful information. While the author expressly disclaims all pretensions to infallibility, he says that every honest effort has been made to verify the assertions given in the book, and that for every statement of fact therein, verification or corroborative evidence of some sort can be furnished. "Very naturally, the men and corporations denounced in former editions of the Copper Handbook are not pleased at the unenviable notoriety given them in a publication of good standing, circulating throughout the world, but it may be said, as an evidence of the thoroughness with which this work has been done in past editions, that, notwithstanding the many threats uttered against the author of this book, ranging from simple threats of corporal chastisement to promises of suits for criminal libel, the author has yet to be thrashed and yet to be sued for any statement contained in the past editions of the work."

The chapter on copper mines of the world covers 684 pages, i. e., over three-fourths of the book. It contains 3,849 titles, with from two lines to fourteen pages devoted to each. The information given covers the names of the principal officers, capitalization, development and present status of the mine property and the processes used. From the statistics given in the last chapter it appears that the average decennial percentage of increase for the last century was 53.91 per cent; for the last half of the century 67.90 per cent; and for the last twenty years, during which the electrical industry became a great consumer of copper, the average decennial increase in copper output was 77.83 per cent.

### The Fery Radiation Pyrometer.

In all pyrometers other than radiation pyrometers there is some part—the sensitive or receptive part—which is made to acquire a temperature identical with the temperature to be measured. With radiation pyrometers this is not the case. For measuring furnace temperatures, for example, with a radiation pyrometer, the pyrometer is entirely outside the furnace.

The advantage of this fact is self-evident, since it is difficult to construct anything of solid material which can be maintained for prolonged periods at a high temperature with-

out suffering some permanent or sub-permanent change in its physical properties, and as we ascend higher in the temperature scale the difficulties increase in a quite disproportionate degree. A further aggravation of the trouble is to be found in the chemical activities of furnace products and furnace gases, which in some cases render difficult the adequate protection of a resistance wire or thermo-couple. All these troubles are manifestly absent in radiation pyrometers, since the instruments are, of course, placed at some distance from the furnace, while no part of them is raised above the air temperature by more than 80 C. degrees. In the following we describe the type of radiation pyrometer, invented by M. Fery, professor of Physics at the Ecole de Physique et de Chimie in Paris.

In the Fery pyrometer the radiation which emanates from a hot body, or which passes out through an observation hole in the wall of a furnace, falls upon a concave mirror or upon a system of lenses, as the case may be, and is thus brought to a focus. In this focus is a thermoelectric couple, whose temperature is raised by the radiation falling upon it; the hotter the furnace the greater the rise of temperature of the couple.

The arrangement of the instruments is such that they are uninfluenced within wide limits by the size of the hot body or observation hole on the one hand, or on the other hand by the distance which separates them from the hot body or furnace.

The absorption of some small amount of radiant heat in passing through the atmosphere cannot, of course, be strictly without effect; but in practice the error thus arising is not appreciable; it has been found, for example, that the reading obtained for the temperature of a stream of molten steel was precisely the same—1,200° C.—whether the instrument was set up 3 feet or 60 feet away.

A complete instrument consists of telescope and galvanometer; fixed within the telescope, at a point upon its optic axis, is the junction of a copper-constant thermo-couple arranged in the form of a cross. The two wires are attached to two brass strips D and R, which are attached to the terminals bb', Fig. 2. The terminals are connected by leads to the galvanometer as shown in Fig. 1.

To use this apparatus for measuring the temperature of a furnace an observation hole in the wall of the furnace is sighted through the eyepiece O, the image of this hole being brought into coincidence with the thermo-junction. It is essential that the image of the observation hole should slightly overlap the junction, which appears to the eye as a black disc in the center of the field of view. The readings of the instrument are then independent of the size of the observation hole.

In the mirror instrument the image of the hole is reflected to the eyepiece O by two small plane mirrors placed close to the couple. These mirrors serve for the adjustment of focus; they are so arranged that the image of the hole appears to be split into two parts, which only blend together to form an unbroken image when the focussing is correct. Fig. 3 illustrates the changes in the appearance of the field as the focus is altered. The middle figure shows exact focus, while the left and the right-hand figures refer to too long and too short a focus respectively.

The image thus formed upon the junction produces a rise of temperature which is shown experimentally to be proportional



FIG. 1.—FERY OPTICAL PYROMETER.

to the amount of radiant energy which enters the telescope. The junction acquires exactly, and with great rapidity, the temperature of the image, but in no case does its temperature rise by more than 80 C. degrees above the atmospheric temperature.

The e. m. f. which is thus generated is measured by a highly sensitive galvanometer whose scale is divided and figured so as to read temperatures directly. This galvanometer, notwithstanding its sensitiveness, is of substantial construction; it comprises a finely pivoted moving coil, provided with a long pointer. The movement of the coil takes place within a single air gap between the poles of a strong permanent magnet.

These galvanometers are invariable in their indications, and unaffected by all external influences. They are self-levelling, so that no adjustment of level is required before a reading is taken. By turning a milled head the moving coil can be freed when a reading is to be taken, or clamped to facilitate the removal of the instrument. Another milled head enables the divided scale to be unclamped, adjusted in position to a small extent and re-clamped, so that the reading is zero when no cur-

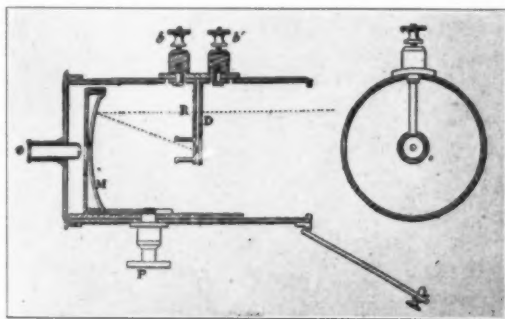


FIG. 2.—CONSTRUCTION OF FÉRY PYROMETER.

rent is flowing. The galvanometer has a resistance of about 10 ohms, and is connected by leads about 10 meters (33 feet) long to the terminals of the pyrometric telescope.

The graduation of the galvanometer scale is based upon the Stefan-Boltzmann law, which expresses the relation between the temperature of a body and the amount of total radiant energy which it emits. The law is as follows: "The radiant energy emitted by a perfectly black body is proportional to the fourth power of the absolute temperature of the body." This law was found by Stefan as a result of experiments, and was later deduced by Boltzmann from thermodynamical reasoning.

In the law, as above pronounced, absolute temperature means, of course, temperature in Centigrade + 273; the statement of the law should be more exact that the total radiated energy is proportional to the difference of the fourth power of the absolute temperature of the radiating body and the fourth power of the absolute temperature of the body on which the radiation falls.

The term "perfectly black," used in the above statement, is, of course, employed in its thermodynamical meaning, namely, that it emits and absorbs all waves of all different wave lengths. This does not mean at all that a body which is called "perfectly black" in thermodynamical sense, has what we call in ordinary life the black color. For instance, as was already proven by Kirchhoff, a furnace, the interior walls of which are on a high uniform temperature and which has only a small hole in the walls, through which it emits radiation (which is observed and measured by a radiation pyrometer), behaves for all practical purposes like an ideal "perfectly black body," although in ordinary life we would call the interior of the furnace red-hot or incandescent white.

If the inner wall of an enclosure E, Fig. 4, is at one temperature throughout, and if an aperture A through which radiant heat emerges is of small dimensions, compared with

the depth of the enclosure behind the aperture, then the radiation proceeding from the surface B of the enclosure will be independent of the character of the surface, and the same as if the surface B were perfectly black. The arrangement sketched in Fig. 4 is one which is actually used in taking furnace temperatures by means of the Féry pyrometer.

Moreover, in many industrial processes, a knowledge of actual temperatures—in Centigrade or Fahrenheit—is not essential, provided some standard is available which serves to distinguish between higher and lower temperatures, and enables correct heat conditions, once obtained, to be reproduced with certainty. Suppose, for example, that we are sighting the pyrometer on the metal in a crucible, and that the reading obtained on the temperature scale of the galvanometer is 1,100° C. Owing to the surface of the metal not being absolutely black this reading may be lower than the true temperature, which we will suppose is 1,180° C.

If we find that the castings obtained by pouring the metal under these heat conditions are satisfactory and better than those resulting from pouring either hotter or colder metal, we shall have reached the important practical conclusion that the correct pouring temperature for the metal in question produces a reading of 1,100° C. on the temperature scale of the galvanometer—even though we do not know the true temperature of the metal on the centigrade scale.

In other words, the indications of the pyrometer are always consistent in themselves, so that it is possible to obtain a permanent record of the temperatures of a metallurgical process. When the proper temperatures have once been determined, they can always be duplicated with the aid of the radiation pyrometer—and this is all that is really needed in metallurgical practice. Even in such cases where the radiation is very different from that of a "black body," as with the white-hot gases from a Bessemer converter (where the optical pyrometer would give temperatures several hundred degrees below the actual temperature), the radiation pyrometer will give the practical man everything he needs, because the indications of the temperatures given by the radiation pyrometer (though not the actual temperatures on the gas-thermometer scale) are consistent in themselves. Therefore, when once the proper



FIG. 3.—EFFECT OF CHANGE OF FOCUS.

series of temperatures in a metallurgical process has been determined and reduced to a permanent record by means of the radiation pyrometer, it can be infinitely repeated. Whether the temperature scale of an optical pyrometer agrees with the temperature scale of the gas thermometer, is a question of no practical interest for the metallurgical or chemical engineer.

Since the energy radiated from a hot body increases very rapidly as the temperature is raised, it follows that the Féry pyrometer is far more sensitive at high than at low temperatures. Temperatures as low as 600° C. can be read, but the instrument is most useful for high-temperature work. As examples of high-temperature measurements made with the Féry pyrometer, we may mention the temperature of the sun (7,800° C.), determined by Prof. Féry, as well as the temperature of the iron in a thermit mould, which was found to be 2,500° C. (over 4,500° F.).

The instrument is thus of especial value for taking such high temperatures as those of molten steel, of gas settings, of glass furnaces, brick kilns and electric furnaces. Its great flexibility and the readiness with which it is sighted enable it to be used for taking the temperature of metal in a crucible



just before pouring, thus ensuring correct casting temperatures, a point which is now known to be of especial importance in the case of steel castings. Forgings, billets, blooms and finished rolled sections are also readily followed through the various operations which have to be performed on them, great progress having already been made in this direction.

A point which may need further explanation is the arrangement that ensures that, within limits, the readings of temperature shall be independent of distance.

Suppose that we are sighting the telescope upon a hot body of limited dimensions. The total amount of radiation reaching the aperture of the lens or mirror will vary with the distance from the hot body, and will be inversely proportional to the square of the distance. If, then, the receptive surface of the thermo-junction were sufficiently extended to receive the whole of the radiation which is converged to a focus by the lens or mirror, we might expect the indications of the galvanometer to fall off as the distance was increased. The thermo-junction, however, is not large enough to receive the whole of the radiation which converges towards it. The real image of the source, formed by the lens or mirror, overlaps the thermo-junction on all sides (Fig. 5a), so that when we approach the source more nearly, thus increasing the size of the image produced, the only effect is to increase the amount of overlapping, while the thermo-junction receives no more radiation than before (Fig. 5b). On the other hand, if we withdraw to so great a distance that the image formed is too small to cover the thermo-junction completely (Fig. 5c) the readings obtained will be too low, and will become lower and lower as we recede further and further from the source of heat.

From the above it will also be readily understood that when we are working at any given distance from the hot body, it is necessary for the body in question to be of sufficient size, otherwise the image of the body would be too small to overlap the thermo-junction on all sides. But provided the hot body is large enough to secure the necessary overlapping, no further increase in its dimensions will add to the amount of radiation actually received by the thermo-junction. The diameter of the hot body (or furnace aperture) should measure as many inches as the distance from hot body to pyrometer measures yards.

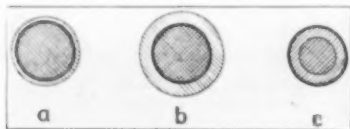


FIG. 5.—EFFECT OF CHANGE OF DISTANCE.

A similar galvanometer is also made and calibrated so as to measure directly low temperatures, the temperature of liquefaction of gases, liquid air and liquid carbonic acid, or for the measurement of moderate temperatures between  $0^{\circ}$  and  $600^{\circ}$  C. In such cases the galvanometer is connected by leads to a copper-constantan thermo-couple immersed in the medium whose temperature is required. The couple is enclosed in a tube which leaves the junction exposed. These couples should never be heated above  $700^{\circ}$  C.

Thus optical pyrometry has now conquered the whole range of temperatures, down to the lowest and up to the highest degrees, and has achieved this result by simple and practical means.

The sole agents for the sale of this instrument in America, Great Britain and her colonies, Norway and Sweden are the Cambridge Scientific Instrument Co., Ltd., in Cambridge, England.



FIG. 4.—APERTURE FOR MEASURING FURNACE TEMPERATURES.

## Hot-Blast Smelting.

In an article in our October issue (page 400) we discussed at length the use of hot blast in its metallurgical consequences and the savings resulting therefrom.

It is, of course, always possible to install a special U-pipe stove for heating the blast, but this may be avoided by utilizing the heat of the furnace itself for this purpose.

Fig. 1 represents the end elevation and section of a modern copper matting hot-blast furnace, built by the Traylor Engineering Co., 118 Liberty Street, New York City, while Fig. 2 represents side elevation and section showing the arrangement of the hot blast attachment of the same furnace. This furnace represents particularly the adaptability of Mr. Joseph L. Giroux's hot-blast equipment.

The illustrations are almost self-explanatory, and it will be seen that the cold blast from the blower enters a horizontal pipe near the top of the furnace and extending transversely across from side to side. The air is then delivered to a series of vertical pipes, through which it passes alternately through the first from top to bottom and then through the next pipe from the bottom to the top, and so on, as indicated by the arrows. The air is thereby heated and is finally delivered into

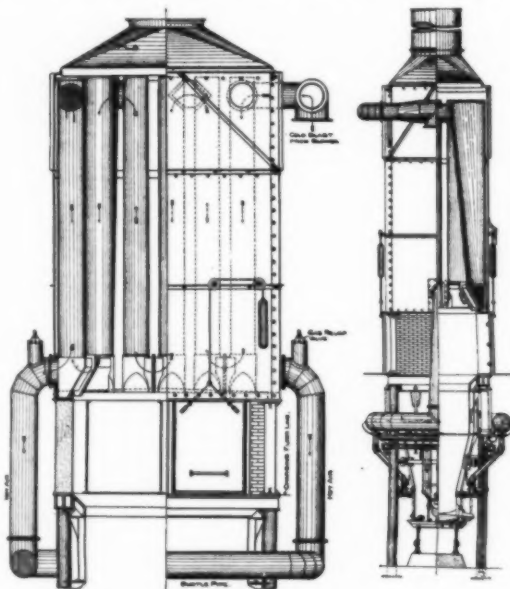


FIG. 1.—COPPER MATING HOT-BLAST FURNACE.

the bustle-pipe, which is connected through pipes with the tuyeres opening into the lower smelting portion of the furnace.

The use of this attachment in connection with all copper-matting furnaces means the saving of from 3 to 6 per cent of coke, this depending largely on the analysis of the ore and the percentage of sulphur available. It is stated that on ores averaging 15 per cent of sulphur and up to 30, the use of this hot blast attachment will more than pay for the cost of installing in from three to six months operation in the saving of fuel alone, as well as materially increasing the smelting capacity over any given size furnace running with cold blast.

CANADIAN COMMISSION REPORT.—The excellent report of the commission appointed by the Canadian Government to study electric iron and steel processes in Europe (see our Vol. II, p. 479), has now been translated into French. Otherwise no changes have been made. A new important report is expected from Dr. E. Haanel after the completion of Dr. Héroult's experiments at the Soo.

### News and Notes.

**AMERICAN ELECTROCHEMICAL SOCIETY.**—At the meeting of the Board of Directors, to be held on Dec. 2, the names of the following gentlemen will come up for election to membership: Louis Ruhl, New York City; Arthur Haug, Peekskill, N. Y.; H. A. Prosser, Elizabeth, N. J.; A. W. Lewin, New Orleans, La.; Francis R. Pyne, Bethlehem, Pa.; Harry R. Lee, South Bethlehem, Pa.; J. S. Bridges, Jr., Boston, Mass.

**ELECTRIC STEEL.**—Messrs. Naylor & Co., 45 Wall Street, New York City, are the American representatives of the Gröndal-Kjellin Co., Ltd., which owns the patents of Gröndal for iron briquetting and of Kjellin for the electric induction furnace for steel manufacture.

**RUTHENBURG STEEL PROCESS.**—According to the *Niagara Falls Gazette* of Nov. 4, a petition of involuntary bankruptcy was filed on Nov. 3 with the clerk of the District Court in Buffalo against the Ruthenburg Reduction Co., on behalf of several local creditors. "The company was forced into bankruptcy owing to difficulties attending the demonstration of the Ruthenburg process for making steel at Niagara Falls. The plant occupied the 'old stone barn,' and an effort was made to adapt it to the work, but it was unsuccessful. The bankruptcy proceedings do not mean, by any means, that the Ruthenburg process is a failure. In fact, it is said that it has practically been demonstrated. It is expected that work will be resumed probably at Niagara Falls on Mr. Ruthenburg's patents by men who are confident of the success of the process. The failure of the Ruthenburg Reduction Co. was caused by the difficulty in obtaining the right equipment for the process."

**OIL CONCENTRATION.**—It is stated that the treatment of low-grade copper ores of the Graham mine at Massey, Ont., by the Elmore oil process of concentrating has proven very successful. During the experimental stage of operating the mine, the Massey Station Copper Co. has expended over \$300,000, and the undertaking is now said to be on a sound commercial basis. From a 3 per cent ore a concentrate of 20 per cent standard is turned out. The Elmore oil concentration plant was installed at Massey to treat the tailings from the usual water concentration plant, and has given so good results that the water concentration plant has been abandoned altogether and the Elmore oil plant is now being doubled in capacity.

The **PHILADELPHIA TESTING LABORATORY** has been established at 808 Chestnut Street, Philadelphia, for carrying on all lines of inorganic analyses and assays. Mr. J. W. Harris is the director of the laboratory.

**GERMAN CHEMICAL INDUSTRY.**—At the annual meeting of the German Association for the Advancement of the Chemical Industry, held in Heidelberg on Sept. 23 and 24, special emphasis was placed on the prosperous conditions existing in this industry, which is justly regarded as the pet industry of the German empire. No other industry in Germany has been so little affected by the business depression of the past four years as the chemical industry. The dividends of 143 stock companies, representing a capital of \$157,913,000, average 9.37 per cent in 1904, as against 8.56 per cent in 1903.

**MESSRS. QUEEN & CO.**, of Philadelphia, have taken the entire second floor of the building at Eighth and Arch Streets, and will dispense with their retail store at 1010 Chestnut Street after Jan. 1, 1906. They will pay in future less attention to photographic apparatus and supplies and will concentrate their energies toward the manufacture of instruments of precision, chemical and physical laboratory apparatus and supplies, optical instruments, etc.

**PORTLAND EXHIBITION AWARDS.**—The Superior Jury at the Lewis and Clark Exposition has approved the following awards in the electrical department, relating to the exhibits of the General Electric Co., which is the largest manufacturer exhibiting in that department. The highest award granted by

the jury is a gold medal. The General Electric Co. received a gold medal for the best exhibit in the electrical department and also gold medals on each of the following features of this exhibit: Curtis steam turbine, meters and instruments, time limit relays and oil switches, switch boards, meter controlling panels, circuit breakers and lightning arresters, direct and alternating-current motors, direct and alternating-current generators, static transformers, automatic voltage regulators, magnetite arc lamp, alternating and direct-current enclosed arc lamps, mercury arc lamps, magnetic starting device for mercury arc lamps, mercury arc rectifier, railway rotors and controllers, mining locomotives, searchlight and method of control, process and development in the art. For its new metalized carbon filament incandescent lamps the company also received a gold medal.

**PLATINUM EXHIBIT.**—Messrs. Baker & Co., Inc., refiners and manufacturers of platinum, gold and silver, Newark, N. J., and New York City, have been awarded a gold medal for the excellency and variety of their exhibit at the Lewis and Clark Centennial Exposition, just closed at Portland, Ore. Being the first exhibit of its character on the Pacific Coast, and located in the Mines and Metallurgy Building, under Government supervision, it attracted the special attention of a large number of visiting miners and metallurgists, who, in recent years, have been devoting greater care to the recovery of the platinum known to exist in the alluvial deposits along the Pacific Coast. The company's exhibit was comprehensive in its character, including numerous samples of crude platinum ore, the salts and solutions of the metal, and various forms of platinum ware, such as are used daily in the arts and industries. A more extensive exhibit, which they displayed at the Louisiana Purchase Exhibition in 1904, was awarded the grand prize.

**BACTERIOLOGICAL APPARATUS.**—We have received from Messrs. Eimer & Amend, of New York City, their revised and enlarged catalogue (1905) of bacteriological apparatus. The catalogue gives descriptions of the latest types of microscopes and accessories, microtomes, incubators, etc., as well as of general laboratory appliances and apparatus, and is well illustrated.

**SAMPLING PLANTS.**—Catalogue 127 of the Allis-Chalmers Co. contains a great amount of useful information on the problem—which is of fundamental importance in every metallurgical plant—how to prepare a proper ore sample. The pamphlet contains well-illustrated and clearly written notes on sampling mills, ore breakers, crushing rolls, sample grinders, automatic samplers, elevators, conveyors, bin gates, grizzlies, ore barrows, scales, Corliss engines, electric generators, motors and accessories.

**ACETYLENE LABORATORY APPLIANCES.**—We have received from the Harris Calorific Co., of 2 Clinton Street, Cleveland, Ohio, their illustrated catalogue of acetylene laboratory appliances for colleges, schools, chemists, assayers and for manufacturing purposes. The flame attainable from acetylene burners has a temperature far beyond that which can be obtained with ordinary gas burners, and is suitable for a great many purposes, like welding and brazing. Temperatures approaching the oxy-hydrogen blow-pipe may be obtained at a very low cost.

**FERRO-SILICON MANUFACTURE.**—The various inherent advantages of the use of high grades of ferro-silicon, made in the electric furnace and containing from 25 to 75 per cent Si over the lower blast-furnace grades of some 10 per cent, are well known to our readers (see, for instance, our Vol. II., p. 122). The fact that the higher the grade the less will be the impurities which are introduced into the steel, was soon recognized by steel men. With the increasing demand for high-grade ferro-silicon many electric furnace plants, which were originally founded to make calcium carbide, turned to the manufacture of ferro-silicon. Competition then became so strong that a syndicate was formed. But the independents are also strongly active. Messrs. George G. Blackwell, Sons &

Co., Ltd., of Liverpool, the well-known British pioneer firm in ferro-alloys, are interested in and represent the largest, newest and most up-to-date ferro-silicon works outside of the syndicate. Mr. George G. Blackwell, chairman of this firm, was recently on an extended trip through the country, visiting all the steel centers. After a visit to Pittsburg and other points he sailed for Europe on December 2.

### Personal.

The wedding is announced of Mr. PAUL OSCAR ABBE, of the Abbe Engineering Co., of New York City, to Miss Henrietta Elvira Eck, daughter of Mr. and Mrs. Gustaf F. Eck, of Brooklyn, N. Y.

Mr. WOOLSEY MCA. JOHNSON, of New York City, will deliver, next February, a series of lectures at Harvard University on the subject of "Applications of Physical Chemistry to Metallurgy."

The partnership between Messrs. A. D. Little and W. H. Walker, under the name of Little & Walker, as consulting chemists, has been dissolved by mutual consent. Mr. ARTHUR D. LITTLE continues the business at the present office of the firm, 93 Broad Street, Boston, Mass., while Mr. WILLIAM H. WALKER carries on his consulting practice at 24 Trinity Place, Boston.

Dr. KARL GOLDSCHMIDT, of Essen-Ruhr, Germany, sailed on November 7 for Europe on the "Kaiser Wilhelm II." On the eve of his departure he gave a delightful dinner at the Waldorf-Astoria to his business associates of the Goldschmidt Thermo Company and to a number of gentlemen whom he had met during his short stay in this country.

Prof. WILHELM OSTWALD, of Leipzig, Germany, is now in this country, lecturing at Harvard University on physical chemistry. On his arrival in the United States and before he proceeded to Boston, numerous receptions were tendered to him in New York City.

Mr. M. FUKUDA, chief engineer of the Osaka Electric Copper Refining & Rolling Co., of Japan, is visiting this country, to study the development of copper refining in the United States.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.—Several changes have taken place in the staff of the Research Laboratory of Physical Chemistry of the Massachusetts Institute of Technology. Prof. W. D. Coolidge has accepted a position in the technical research laboratory of the General Electric Co., at Schenectady, where he will be closely associated with Dr. W. R. Whitney. Mr. Yogoro Kato has accepted a position in the Technical High School of Tokio, where he will have charge of the work in electrochemistry. Mr. Wilhelm Böttger returns as privatdocent to the University of Leipzig, at which he will conduct one of the laboratory courses in analytical chemistry. In place of these retiring members the following gentlemen have received appointments to the research staff: Dr. William C. Bray, Mr. Guy W. Eastman, Dr. Gilbert M. Lewis and Mr. Edward W. Washburn. Mr. Roy D. Mailey has been promoted to the position of research associate. Seven candidates for the degree of doctor of philosophy are now pursuing work in the laboratory.

### Digest of U. S. Patents.

Compiled by Byrnes & Townsend,  
Patent Lawyers,  
National Union Building, Washington, D. C.

#### TREATMENT OF CARBON AND PRODUCTION OF GRAPHITE.

No. 354,310, Dec. 14, 1886, Thomas A. Edison, Menlo Park, N. J.

Produces rods of pure carbon by electrically decomposing a

hydrocarbon liquid or gas. An arc is sprung between the ends of horizontal electrodes submerged in a hydrocarbon oil, and the electrodes are gradually separated. One electrode consists of a piece of carbon; the other of a platinum or carbon rod or wire of relatively small area. The oil is decomposed by the heat of the arc, and carbon deposits on the end of the smaller electrode and gradually builds out into a rod as it is withdrawn.

No. 542,982, July 23, 1895, E. G. Acheson, Monongahela City, Pa.

Purifies carbon by electrically volatilizing the contained impurities, as silica, lime and sulphur. For example, granulates coke and feeds it downward between the opposed ends of horizontal electrodes passing through the side walls of an electric furnace. The time of heating is controlled by the rate of withdrawal of the product. The purified carbon is used for arc-light rods, electric contacts, etc.

No. 568,323, Sept. 29, 1896, E. G. Acheson, Monongahela City, Pa.

Converts carbonaceous materials, such as mineral coal, coke, charcoal, gas-carbon and carbides into practically pure graphite, by employing a material containing a considerable proportion of mineral matter, or mixing with it an oxide, or oxides, such as silica, clay, alumina, magnesia, lime or iron oxide, and heating the mixture in an electric furnace. The mixture may consist of powdered coke, 50 per cent; sand, salt and sawdust, and the heating may be effected by placing it in a furnace around a granular carbon core, extending between terminal rods of carbon in the end walls. Upon passing an electric current through the resistance core, the carbon in the charge, or portions thereof, react on the sand, and there is thus initially formed around the core a layer of amorphous and crystalline silicon carbide, which gradually increases. The current is then continued until the temperature rises to a point sufficient to decompose the silicon carbide and volatilize the silicon, the carbon remaining in graphitic form. The graphite thus formed around the core then carries the electric current and furnishes heat to decompose more of the surrounding carbide, and graphite is thus produced and deposited on the core until it nearly reaches the walls of the furnace. For a furnace having a core of granular coke 7 feet long and 4 inches wide, the initial current may be 50 amps. at 650 volts, increasing, as the graphite is formed and enlarges the core to 1,000 amps. at 100 volts. When the carbonaceous material to be treated contains an unusual amount of ash, the oxide added should be correspondingly diminished, and if it contains more than enough impurities the charge may consist of a mixture of the impure carbon with hard coal or coke. The carbonaceous material should contain little volatile matter, to prevent loss of electrical energy by distillation. The process may be carried out in two separate furnaces or stages, silicon carbide, in its crystalline or amorphous form, being made in one operation, and subsequently heated to the temperature necessary to effect dissociation.

No. 598,549, Feb. 8, 1898, Herbert H. Wing, Buffalo, N. Y.

States that amorphous carbon may be converted into graphite by prolonged heating at a high temperature, without the intermediate production and decomposition of carbides. For example, heats coarsely powdered coke in an electric furnace by employing it as a resistor, the temperature being just below the volatilization point of carbon. Illustrates a furnace having a vertical air-tight chamber with carbon lining, a depending-carbon electrode and horizontal screw conveyors, with double-valved hoppers leading through opposite sides. The chamber opens below into a water-jacketed metal receiver, in which the graphite and carbon are cooled without exposure to air. To best utilize the electrical energy, only a portion of the carbon is graphitized, the remainder being dissolved out by an active oxidizing agent; e. g., a mixture of a chlorate and nitric or sulphuric acid, or both.



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